Building NOAA's Environmental Real-time Observation Network

Site Maintenance Plan

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U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service

Signature/Approval Page

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Site Maintenance Plan

Approved:

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U.S. Department of Commerce
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1 Introduction

These maintenance procedures are intended to ensure uniform station and sensor maintenance and to maximize safety, data quality, and equipment reliability across NOAA's Environmental Real-time Observation Network (NERON). The intent is to provide organizations contracted to maintain NERON stations with explicit and clear instructions about how the NERON Project Office expects the equipment and sensors to be maintained, reducing confusion and cost and resulting in a world-class climatological and meteorological observing network.

This document is formatted as a field reference manual that can be taken into the field by technicians. Page breaks have been inserted before all major sections and to separate procedures so that they can be located easily by scanning the headings at the tops of pages and so that the manual can be laid open to a single procedure at a time.

2 Station Configuration Figures

The figures on the following pages show how the three types of station (3-meter tower on small plot, 3-meter tower on large plot, tall tower on large plot) are configured in NERON.

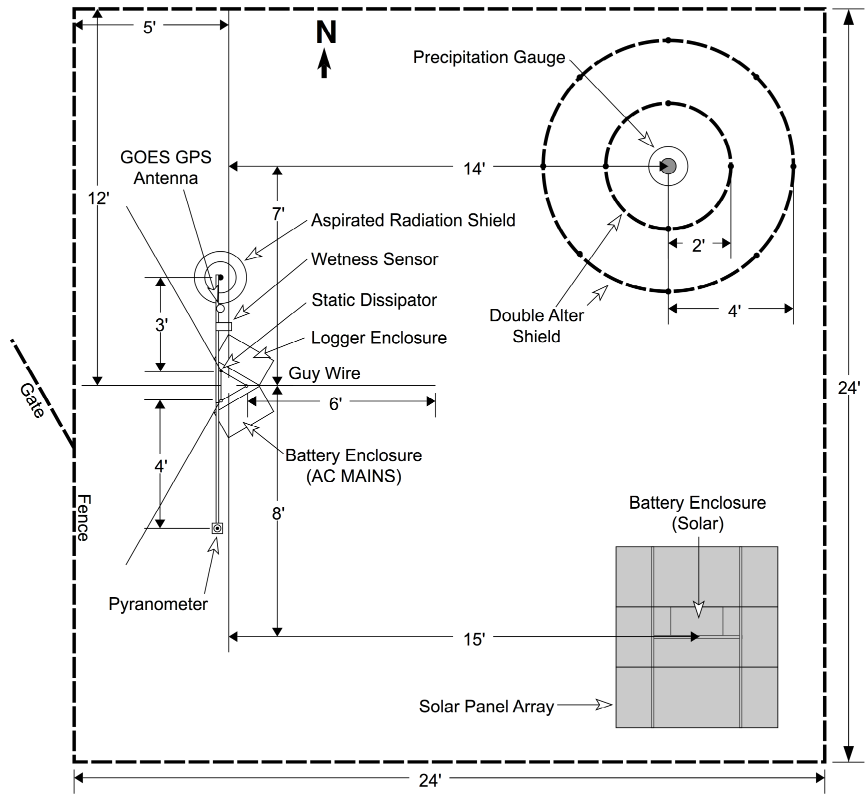

Figure 1. Plan view of a station with a 3-meter tower on a small plot.

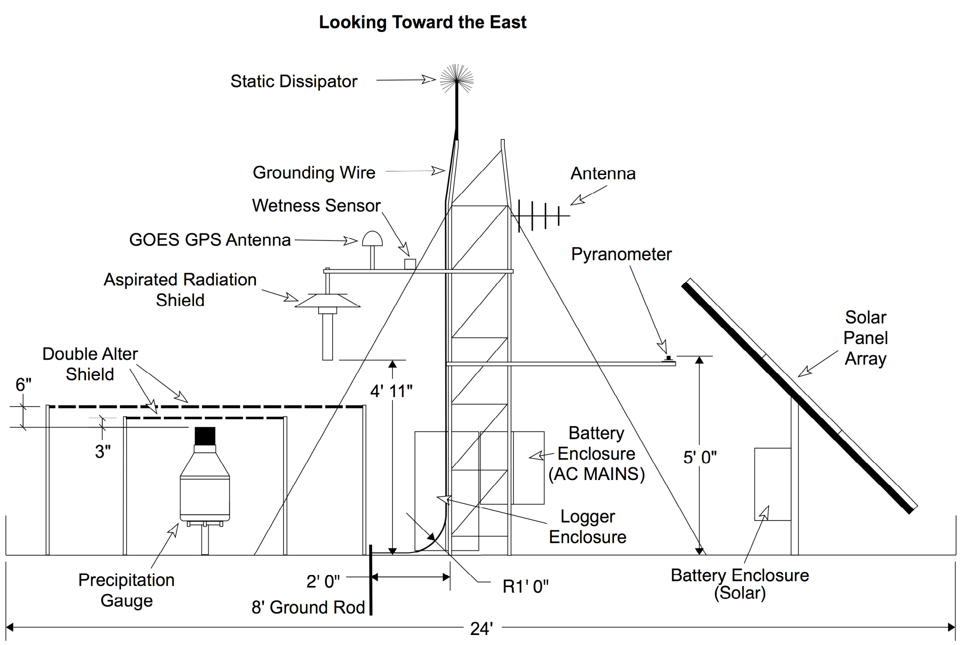

Figure 2. Profile view of a station with a 3-meter tower on a small plot.

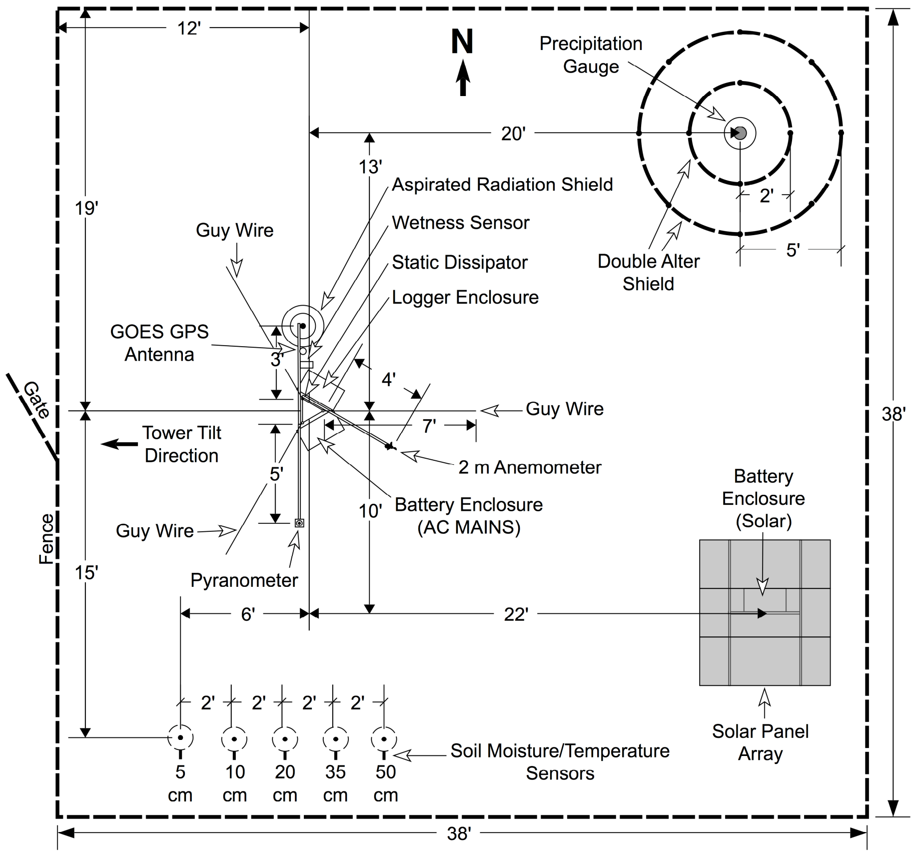

Figure 3. Plan view of a station with a 3-meter tower on a large plot.

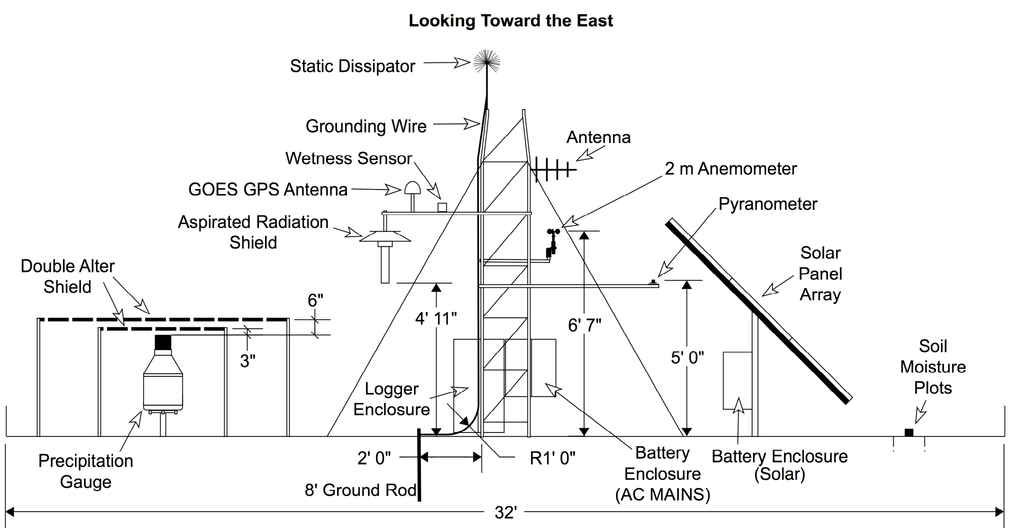

Figure 4. Profile view of a station with a 3-meter tower on a large plot.

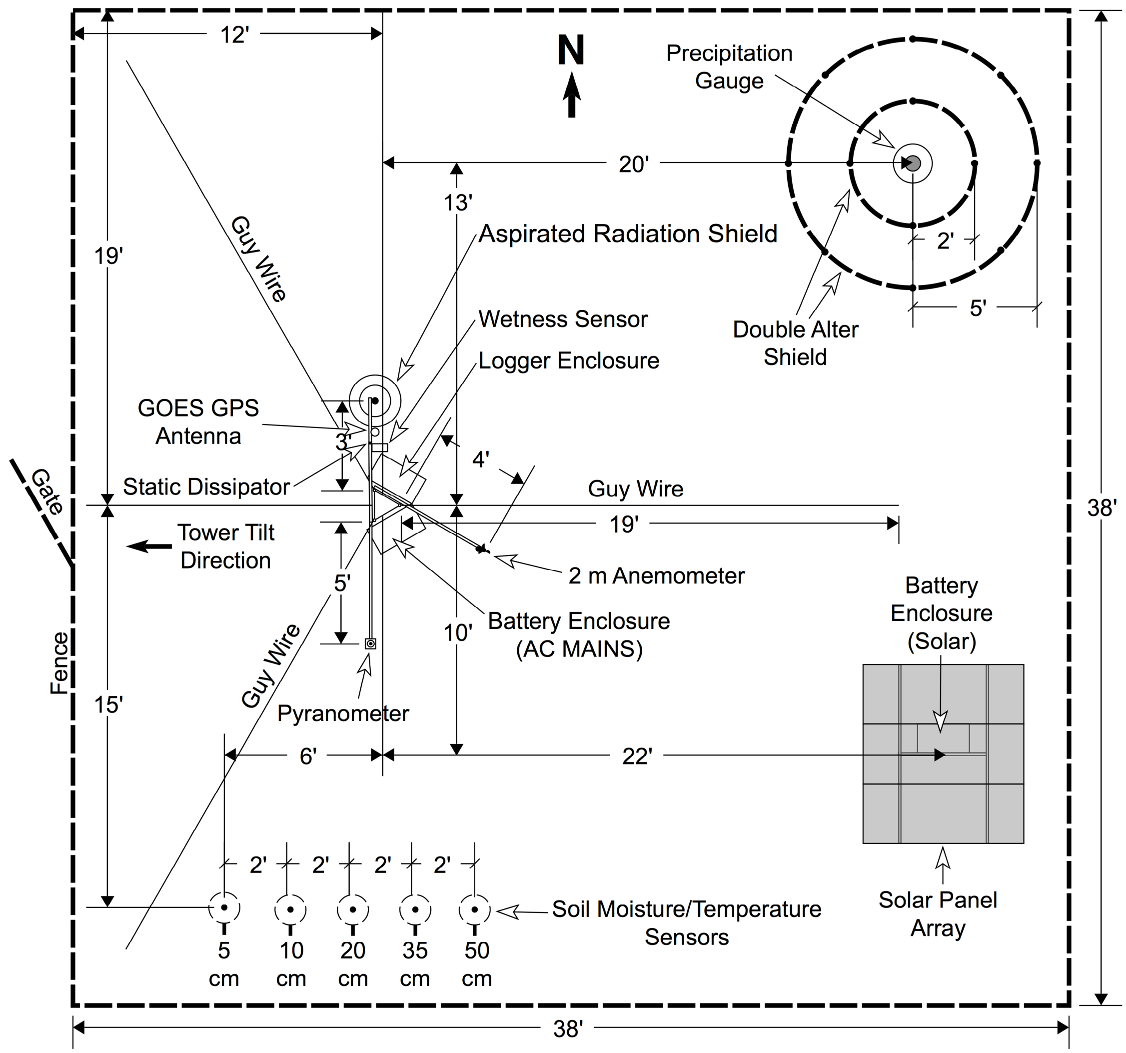

Figure 5. Plan view of a station with a tall tower on a large plot.

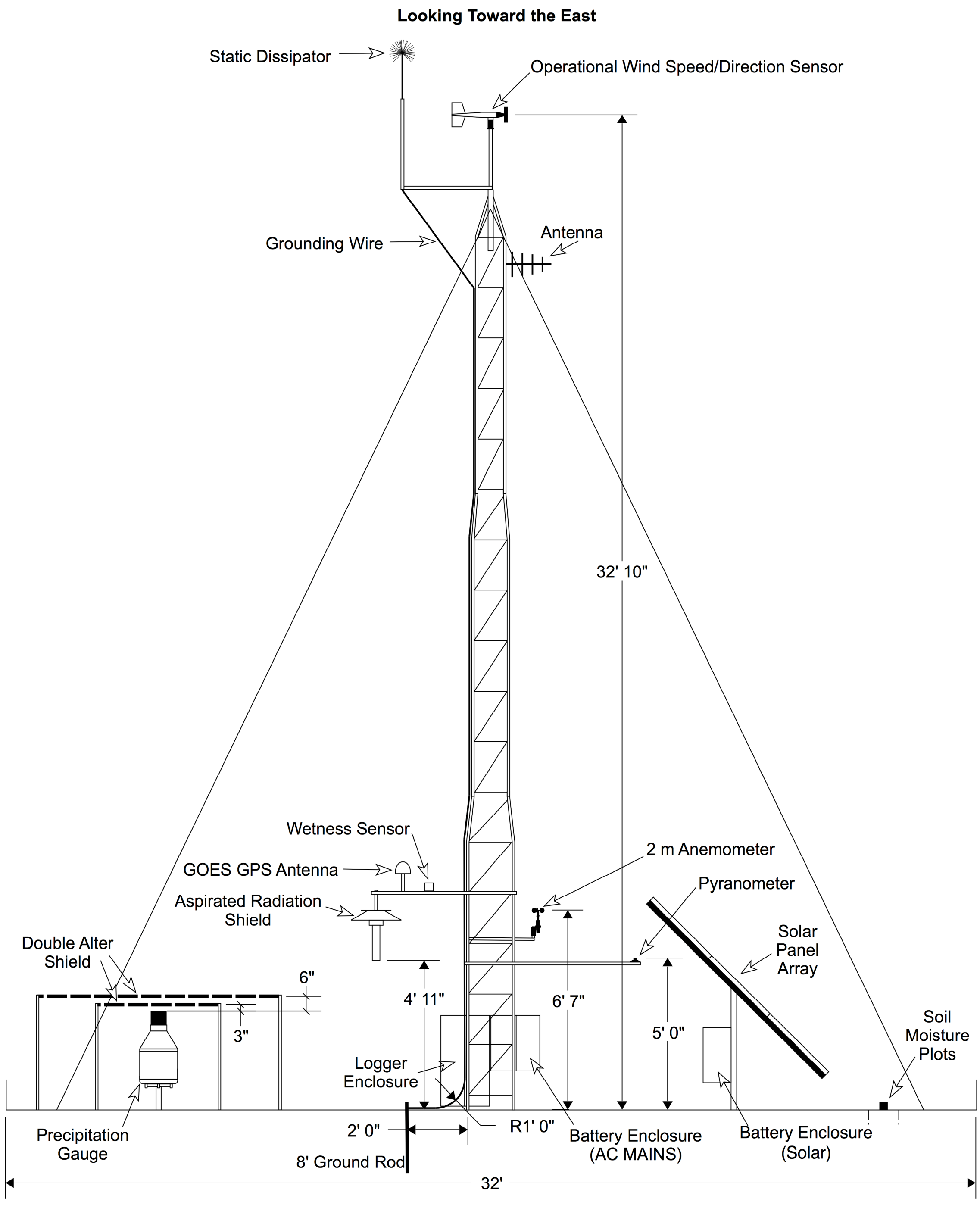

Figure 6. Profile view of a station with a tall tower on a large plot.

3 Routine Maintenance

3.1 Maintenance Performed by Technicians

The maintainers contracted to perform maintenance on NERON stations will make at least two visits to remote weather stations for routine maintenance per year: one in Spring and another in Fall. In addition, the maintainer will make one visit per year to each repeater and base station. The required tasks, which are explained in detail below, include documenting vegetation height and type on arrival and departure and any conditions that might affect sensor exposure or performance photographically, cutting the vegetation on the station plot, inspecting and cleaning sensors and equipment, emptying the weighing bucket precipitation gauge, adding oil and removing and adding antifreeze to the weighing bucket precipitation gauge, rotating sensors for calibration, performing a field intercomparison with reference sensors, and inspecting and adjusting guy wire hardware at tall tower sites.

3.1.1 Visit Schedule

3.1.1.1 Remote Weather Stations

Visits for routine maintenance will be required at the following times, driven by precipitation gauge and vegetation maintenance requirements (the Spring and Fall maintenance visits at remote stations and the yearly maintenance visit to repeater and base stations will be referred to throughout this document as *scheduled* maintenance visits, whereas all other visits will be referred to as *unscheduled* visits):

- Spring (scheduled): remove antifreeze from the weighing bucket precipitation gauge. Spring maintenance is to be completed no later than two months following the "Remove Mixture Date" for each climate division given in the precipitation gauge antifreeze guide in the appendix.
- Fall (scheduled): add antifreeze to the weighing bucket precipitation gauge. Fall maintenance is to be completed no later than the "Add Mixture Date" given for each climate division in the precipitation gauge antifreeze guide in the appendix.
- Whenever the weighing bucket precipitation gauge's bucket reserve capacity is less than 150 mm (6 in.), to empty the bucket (unscheduled),
- Whenever the vegetation on the site plot reaches a height of 4 feet or higher or anomalies are detected in sensor readings likely to be caused by excessively high vegetation (unscheduled).

Every routine maintenance task should be performed at the spring and fall visits. The following tasks should be performed at every visit:

- Take photos every time the vegetation is cut.
- Visually inspect the mast or tower, enclosures, radiation shields, sensors, precipitation gauge, cables, terrain, and vegetation for abnormalities and obstructions, documenting abnormalities photographically.
- Cut the vegetation if it is taller than 12 inches.

- Inspect and, if necessary, clean the radiation shields, solar panel, pyranometer, and skin temperature sensor, except that the solar panel need not be cleaned at a tall tower site unless it is dirty enough that the solar cells are not visible beneath the clear surface over a portion of the panel.
- If out of level, level the pyranometer.
- Replace desiccant, if required for the enclosure installed at the site, and if the current desiccant will be older than 6 months before the next visit.
- If more than 0.5 inches of rain have fallen since the precipitation gauge bucket was last emptied and climatology or forecasts suggest that it would need to be emptied again before the next scheduled maintenance visit, empty the precipitation gauge bucket and, if the visit is during the winter season, add antifreeze.

3.1.1.2 Repeater and Base Stations

Visits for routine maintenance at each repeater and base station will be required once per year, scheduled at the discretion of the maintainer, with the restriction that the time between visits at any one station does not exceed 14 months.

3.1.2 Documentation

3.1.2.1 Remote Weather Stations

All scheduled maintenance visits should be documented by completing the NERON Remote Station Maintenance Form for Technicians, found in the forms section of this document. If a printed paper version of the form is used by the technician in the field, the information entered by the technician must be transcribed to the electronic version and sent to the NERON QA staff by FTP, as described in Section 5, Submission of Documentation, on Page 57, within 5 business days after completing the maintenance. The following paragraphs explain how the maintenance form should be completed, item-by-item.

"Station ID" is the 3- or 5-character station identifier. Note the date and time of arrival and departure in UTC, as indicated by the station's data logger.

Note: The logger enclosure should be opened and kept open throughout each maintenance visit to ensure that the technician visit flag is set to properly flag the data. The first step upon arriving at a site should be to open the enclosure, and the last step upon departing should be to close the enclosure.

Enter the name of the maintenance contractor and the name of the technician performing the maintenance in the indicated boxes. Place "X's" in the check boxes next to each task completed.

1. Arrival Photos. Before performing any maintenance, take arrival photos, as explained in the photographic documentation section below. The codes indicate the photo naming convention to use for each photo, and the blank spaces to their right can be used to record the ID number assigned to each photo by the digital camera to avoid confusion when renaming the photos later.

2. Visual Inspection. The results of the visual inspection should be indicated with a "Y" for "yes" and an "O" for "no" in each box in the visual inspection section. All abnormalities and obstructions removed should be explained in the notes section on the back of the form.

3. Vegetation Maintenance. Mark the check box to indicate that the vegetation has been cut as specified in the vegetation maintenance section below.
4. Tall Tower Maintenance. Mark all check boxes to indicate that all required tall tower maintenance has been completed at tall tower sites, as specified in the Tall Tower Maintenance section below.
5. General Maintenance. Indicate the completion of cleaning, leveling, and wind sensor maintenance, using a "Y" for "yes," an "O" for "no," or a "—" for not applicable in each box in the tables. In addition, enter an "NC" in the "DIRTY BEARINGS" box for the operational wind sensor (WSPD) if the tower was not lowered and the sensor was not checked. Mark the additional check boxes to indicate that all additional general maintenance has been completed.
6. Precipitation Gauge Maintenance. Mark all of the applicable check boxes to indicate that all maintenance appropriate to the season has been completed. In addition, enter the results of the calibration verification, if performed, and include the serial numbers of the precipitation gauge base and each vibrating wire sensor. If adding antifreeze to the bucket, indicate the amount in liters.
7. Sensor Rotation. If rotating any sensors, for either scheduled rotation or a problem, check the boxes of each sensor rotated. Fill out an individual trouble ticket form for a single sensor, or a mass install trouble ticket form for multiple sensors, or if replacing additional equipment.
8. Communication System Maintenance. Mark all check boxes to indicate that all required inspections have been completed. At sites without cellular modems, measure the forward and reflected RF power while transmitting, and indicate the values in watts in the "Arrival" row of the table. If the radio, antenna cable, or antenna are replaced, repaired, or adjusted, perform another test afterward and enter the values in the "Departure" row. Due to the infrequency of GOES transmissions, a second RF test may not be possible but should be performed if reasonably possible.
9. Departure Photos. After all maintenance is complete, but before securing the logger enclosure, take the departure photos, as explained in the photographic documentation section below. Identify and explain any notable findings photos that were taken in the notes section on the back of the maintenance form.
10. Mark each check box to indicate that each final step was completed.
11. Documentation Submitted to NERON QA staff. Mark each check box to indicate that all required documentation has been submitted to the NERON QA staff.

Finally, the maintenance contractor's representative to the NWS should enter her/his name and enter the date of submission.

3.1.2.2 Repeater and Base Stations

All scheduled maintenance visits should be documented by completing the NERON Repeater and Base Station Maintenance Form for Technicians, found in the forms section of this document. If a printed paper version of the form is used by the technician in the field, the information entered by the technician must be transcribed to the electronic version and sent to the NERON QA staff by FTP, as described in Section 5, Submission of Documentation, on Page 57, within 5 business days after completing the maintenance. The following paragraphs explain how the maintenance form should be completed, item-by-item.

"Station ID" is the 3- or 5-character station identifier. Note the date and time of arrival and departure in UTC. Enter the name of the maintenance contractor and the name of the technician performing the maintenance in the indicated boxes. Place "X's" in the check boxes next to each task completed.

1. Visual Inspection. The results of the visual inspection should be indicated with a "Y" for "yes" and an "O" for "no" in each box in the visual inspection section. All abnormalities and obstructions removed should be explained in the notes section at the bottom of the form.
2. Tower Maintenance. Mark the check boxes to indicate that all required tower maintenance has been completed at repeater stations with towers owned by NWS specifically for NERON, as specified in the Tall Tower Maintenance section below.
3. General Maintenance. Indicate the completion of cleaning, leveling, and wind sensor maintenance, using a "Y" for "yes," an "O" for "no," or a "—" for not applicable in each box in the tables. Mark the additional check boxes to indicate that all additional general maintenance has been completed.
4. Communication System Maintenance. Mark all check boxes to indicate that all required inspections have been completed. At sites without cellular modems, measure the forward and reflected RF power while transmitting, and indicate the values in watts in the "Arrival" row of the table. If the radio, antenna cable, or antenna are replaced, repaired, or adjusted, perform another test afterward and enter the values in the "Departure" row. Due to the infrequency of GOES transmissions, a second RF test may not be possible but should be performed if reasonably possible.
5. Mark each check box to indicate that each final step was completed.
6. Documentation Submitted to NERON QA staff. Mark each check box to indicate that all required documentation has been submitted to the NERON QA staff.

Finally, the maintenance contractor's representative to the NWS should enter her/his name and enter the date of submission.

3.1.3 Photographic Documentation

Photos should be taken with a digital camera set at its highest picture quality setting. The submitted photos should be JPEG format and 640 x 480 pixels in size. Except for notable findings photos, all photos should be taken in landscape, rather than portrait, orientation. If possible, set the camera to stamp the current date in the bottom corner of each photo. The photos should be taken with enough ambient light to clearly see the subjects of interest; photos after sunset, before sunrise and at night should be avoided, if possible. The photos should be named according to the following convention:

STIDYYYYMMDDX#.jpg

where

STID = the 3- or 5-character station ID
YYYY = year
MM = month
DD = day of the month
X = the code given in bold type for each photo in the list below
# = number the photos if multiple views are photographed for a single item.

Note: All compass directions referred to are referenced to true north.

<u>On Arrival</u>

1. East Soil Moisture Plots. From a position 2 feet north of the 4-inch soil moisture marker, showing the markers and the 2-foot-by-2-foot plots centered over the 2-inch, 4-inch, and 8-inch sensors: **SMEA**
2. West Soil Moisture Plots. From a position 2 feet north of the midpoint between the markers for the 20-inch and 40-inch soil moisture markers, showing the markers and the 2-foot-by-2-foot plots centered over the 20-inch and 40-inch sensors: **SMWA**
3. Inside Vegetation Height. Place the vegetation height gauge 4 feet east of the mast or tower. At the northwest corner of the site plot, place the camera at the height of the tops of the vegetation and point the camera so that both the mast/tower and height gauge are in the frame: **IHA**
4. Outside Vegetation Height. Place the vegetation height gauge 10 feet south of the midpoint of the south edge of the station plot. Stand at a position directly south of the height gauge, just far enough from the site plot for the entire plot to fit in the camera's horizontal field of view, place the camera at the height of the tops of the vegetation, and point the camera so that the height gauge is in the center of the frame: **OH**

<u>Notable Findings</u>

Document notable findings that could affect sensor readings, equipment performance, safety, or that document theft or vandalism, such as wasp nests built on temperature or relative humidity sensors, visible lightning damage, guy wire damage, etc., using the parameter ID as shown on a trouble ticket form for sensors or a logical string of no more than 5 characters for other photos.

Give each photo string and an explanation in the notes section of the maintenance or trouble ticket form.

<u>On Departure</u>

1. East Soil Moisture Plots. Same positions as described above: **SMED**
2. West Soil Moisture Plots. Same positions as described above: **SMWD**
3. Inside Vegetation Height. Same position as described above: **IHD**

<u>Other</u>

- Photo of GPS display, showing the reading taken at the center of the site plot, to accompany an installation, move, or update metadata form: **GPS**

<u>Example:</u>
The following example indicates the proper naming of photos for a fictitious maintenance visit on June 6, 2005, to North Foster, RI (FTFR1), as if it had all extended sensors installed:

FTFR120050606SMEA.jpg – arrival photo of east soil moisture plots
FTFR120050606SMWA.jpg – arrival photo of west soil moisture plots
FTFR120050606IHA.jpg – arrival photo of inside vegetation height
FTFR120050606OH.jpg – photo showing outside vegetation height

FTFR120050606TAIR.jpg – notable finding photo showing a wasp nest built on the air temperature sensor
FTFR120050606GUYD.jpg – notable finding photo showing damage to a guy wire

FTFR120050606SMED.jpg – departure photo of east soil moisture plots
FTFR120050606SMWD.jpg – departure photo of west soil moisture plots
FTFR120050606IHD.jpg – departure photo of inside vegetation height

3.1.4 Visual Inspection

Inspect the equipment listed below for any abnormalities, or obstructions, noting any findings or actions taken to fix any problems on the site maintenance or site visit form:

- Mast or tower
- Logger and battery enclosures
- Sensor radiation shields
- All sensors, including sub-surface sensor plots
- Precipitation gauge
- All sensor and electrical cables
- Terrain in and surrounding the site plot
- Vegetation in and surrounding the site plot

3.1.5 Vegetation Maintenance

Cut vegetation to a height between 1 and 3 inches over the entire plot to provide a firebreak around the station equipment and to prevent the vegetation from growing high enough to impede wind flow to the above-ground sensors. Use either a string trimmer or a hand-pushed lawn mower.

Rake the grass and dispose of it as allowed by the site host. If the host does not object to leaving the grass on the ground outside the station plot, deposit it so that it is downwind of the station relative to the prevailing wind directions, if possible, to avoid affecting sensor readings.

3.1.6 Tall Tower Maintenance

Use a level held against the tower to check tower plumb, and adjust the guy wire turnbuckles to plumb the tower, if necessary. Take cross readings with the level to ensure plumb in both dimensions. It is easiest to use two magnetic levels, which can be stuck in place to the tower.

Adjust the guy wire tension to prevent the top of the tower from wobbling excessively. This could affect the wind and pyranometer readings and put excessive stress on the guy wires and anchors in high winds. Leave some slack in the warm months so that when the guy wires contract in the cold months, they won't pull the tower base into the ground.

Perform the following safety inspections once per year:

1. Inspect the guy wire anchors to verify that they aren't loose and haven't moved upward since being installed.
2. Inspect the guy wire hardware, tighten any loose hardware, and replace any rusted hardware.
3. Inspect the guy wires, making sure they aren't frayed or rusted.
4. Inspect the tower base to make sure that it is adequately anchored and hasn't moved since being installed.
5. Inspect the tower to verify that it isn't rusted or bent.
6. Inspect the tower hardware, tighten any loose hardware, and replace any rusted hardware.

3.1.7 Lowering and Raising a Tall Tower

At tall tower sites, the tower should be lowered to perform maintenance on the operational wind sensor, the communication antenna, and the solar panel. Note that this only needs to be done once per year. The procedures for lowering and raising the tower are listed below. A gin pole and a vehicle fitted with an electric winch are required. The gin pole provides mechanical advantage when the tower is near horizontal by elevating the erection cable.

Lowering

1. Position the vehicle on a bearing of 240° true from the tower with its winch oriented toward the tower.
2. Set up the gin pole and feed the winch cable attached to the tower through the gin pole's pulley.
3. Attach the winch cable to the tower and take up the slack with the winch.
4. Disconnect the southwest guy wire from its anchor by unscrewing its turnbuckle.
5. Place a support on a bearing of 60° true from the tower to hold the top of the tower a few feet above ground level when it is lowered.
6. Carefully lower the tower onto the support. Use the north and southeast guy wires to prevent the tower from swaying to either side as it is lowered.

Raising

1. Verify that the gin pole, winch cable, and vehicle are in position and secure.
2. Carefully raise the tower to its vertical position. Use the north and southeast guy wires to prevent it from swaying to either side.
3. Reconnect the southwest guy wire to its anchor by screwing the turnbuckle eye attached to the guy wire into the turnbuckle until there is not slack in the guy wire.
4. Disconnect the winch cable from the tower and take the gin pole down.
5. Adjust the guy wires to plumb the tower and set the guy wire tension. The tension should be left slightly loose during the warm season to prevent contraction in the winter from pulling the tower base into the ground.

3.1.8 General Maintenance

General maintenance includes cleaning and leveling sensors and equipment, checking wind sensors for noisy bearings, replacing desiccant in the logger enclosure, tightening wire terminals, verifying the operation of the door switch, and performing a load test on all batteries. At tall tower sites, it is only necessary to maintain the operational wind speed sensor, solar panel, and antenna, for which lowering the tower is necessary, once per year.

3.1.8.1 Cleaning

Check the radiation shields and solar panel for dirt or obstructions every visit, whether for maintenance or to fix a problem, and clean them if their surfaces are dirty or covered with snow. A radiation shield qualifies as dirty if there are any substances on it that are darker than its white surface, which could absorb solar radiation and heat the shield more than if clean, or if there are any objects that could obscure air flow over the sensor. A solar panel qualifies as dirty if there are any substances or obstructions visible that could reduce the amount of solar radiation reaching the solar cells. Clean the radiation shields and solar panel at least once per year, even if they appear to be clean.

Check the battery and voltage regulator terminals for corrosion at every scheduled maintenance visit (i.e., once in the spring and once in the fall) and clean them with a wire brush to remove any corrosion. At sites where this is a recurring problem, apply petroleum jelly to the terminals to seal out oxygen and prevent corrosion.

3.1.8.2 Cleaning/Leveling

Note that at a tall tower site, the leveling should only be done after the tower has been raised for the final time and after the guy wires have been adjusted to bring the tower into plumb.

The pyranometer lens should be checked for dirt and cleaned if dirty at every site visit. It qualifies as dirty if there are any foreign substances or objects visible on the lens or that obstruct the lens's views of the sky or ground, as applicable. It should be cleaned at every scheduled maintenance visit, even if it appears clean. The pyranometer can be cleaned with water and a soft paper towel.

The precipitation gauge level should be checked at every visit during which the precipitation gauge top is removed. Remove the bucket and check the level of the base by placing a level on the top of the gauge flange from which the vibrating wire sensors hang. Take cross readings to ensure level in both dimensions. Adjust the level of the base by adjusting the three bolts and leveling nuts at the bottom of the gauge. Replace the bucket and level it by adjusting the nuts that secure the vibrating wire sensors. Leveling the bucket is critical, since it ensures that each vibrating wire shares the weight of the bucket equally.

3.1.8.3 Wind Sensor Maintenance

During the spring and fall scheduled maintenance visits, check both the 2-meter anemometer and the operational wind sensor for bearing noise that indicates the presence of dirt, which introduces excessive friction. Listen for a grinding or rattling sound. A clean hissing sound after a sensor has been deployed for a number of months is normal and does not qualify as "noisy."

The 2-meter anemometer cups and the operational wind sensor propeller should be cleaned if fouled with spider webbing or excessively dirty, since those conditions could alter the wind flow around the cups or propeller.

3.1.8.4 Other General Maintenance

Replace the logger enclosure desiccant with 16 units (16 oz.) of desiccant every 6 months, or at least during the spring and summer scheduled maintenance visits.

During the scheduled maintenance visit in the spring, tighten all wire terminal connections in the logger enclosure, battery enclosure, and in the precipitation gauge.

Verify that the door switch is operating correctly by verifying that the door open indication in the logger is active with the switch in the door open position, that the door closed indication becomes active with the switch in the door closed position, and that the indication returns to the door open indication when the switch is returned to the door open position.

Perform a load test on each battery with a 12-volt battery load tester that can be set at a range of amp ratings. The batteries must be fully charged to test them, so if there was little direct sunshine on the previous day and little during the current day, then the batteries cannot be tested. Choose the amp setting appropriate for the battery to be tested, which is determined by the current capacity of the battery. If the battery has a cold cranking amp rating, set the tester for half of that value. Load the battery for the time period specified in the tester instructions and read the voltage. Replace any batteries that fail the test.

3.1.9 Precipitation Gauge Maintenance

Precipitation gauge maintenance includes emptying the gauge bucket (and refilling it with antifreeze if during the winter season), verifying the operation of the rim heater, and recalibrating the three vibrating wire sensors or performing a calibration check.

The bucket must be emptied at each scheduled maintenance visit, and it must be emptied at an unscheduled visit if more than 0.5 inches of rain have fallen since the precipitation gauge bucket was last emptied and climatology or forecasts suggest that it will need to be emptied again before the next scheduled maintenance visit.

The gauge must be fully recalibrated when any of the following occurs:

- one of the sensors is replaced,
- the calibration verification indicates that the average of the depths reported by the three sensors is off by more than 2% from the expected value, or
- any one sensor's reported depth is off by more than 3% from the expected value.

A calibration verification is required once per year, except in years when the gauge has already been fully calibrated.

3.1.9.1 Emptying the Precipitation Gauge Bucket

(Adapted from NOAA ATDD "Precipitation Gauge Maintenance Guide")

1. Refer to the maps in the Precipitation Gauge Antifreeze Guide in the Site Maintenance Plan Appendices to determine the station's climate division. Find the climate division's entry in the antifreeze table, which is also located in the precipitation gauge antifreeze guide in the appendix, and read straight across to determine the add mixture date and the amount to add. Remove the mixture at the remove mixture date. If the current date is later than the remove mixture date and earlier than the add mixture date (warm months), then skip to step 3.
   Note: The antifreeze to be used is propylene glycol.

2. Refer to the Material Safety Data Sheets for proper handling procedures. Pre-measure the required amount of anti-freeze mixture for the precipitation gauge, using a 2-liter measuring beaker. An additional bucket will be required if more than 2 liters of antifreeze must be added.

3. Pump the liquid from the gauge into a bucket that can hold at least 3.5 gallons, as shown, using the gauge siphon.



4. Dispose of the liquid. If the liquid is water only, then pour into a storm drain or spread on the ground. If the liquid contains anti-freeze, then pour it into a carboy for proper disposal.

5. Slowly pour the new anti-freeze mixture into the top of the gauge, if the current date is later than the add mixture date and earlier than the remove mixture date (cold months).


3.1.9.2 Rim Heater Check

Note: The precip gauge cover must be on and its heater connector connected to the precip signal cable connector before beginning the test. Otherwise, the heater and precip rim temperature sensor will not be connected to the system.

1. Using either the logger keypad or a laptop, find and display the HEAT_TEST variable.
2. Activate the heat test by changing the HEAT_TEST variable value to 1. Within a few seconds, the heater relay should turn on.
3. Check the FLPHTR_I variable to confirm that its value changes from 0 to 1 when the heater turns on.
4. Check the TPRECP_I variable to confirm that the rim temperature rises.
5. Wait until the beginning of the next even five-minute period after beginning the test and check the FLPHTR variable to confirm that it changes from 0 to 1.
6. Confirm that the heater automatically turns off five minutes after the test was started and that the logger sets the HEAT_TEST variable back to 0.

3.1.9.3 Calibration Verification

1. Empty the gauge bucket, clean it to remove all foreign matter and liquids, and dry it, disposing of antifreeze as specified in Section 3.1.9.1 on Page 16, Emptying the Precipitation Gauge Bucket.
2. Level the gauge frame and the bucket.
3. Enter the serial numbers of the gauge base and each of the three vibrating wire sensors on the maintenance form.
4. Place either the aluminum base/centering calibration weight or 1000 ml of water, measured with a volumetric flask, in the bucket, wait two minutes, and record the precipitation values reported by the individual sensors, their average, and the percentage differences from the goal value of 50.0 mm on the site visit data verification form.
5. If the precipitation value reported by any individual sensor differs from 50.0 mm by more than 3%, then check the coefficients entered in the logger to confirm that they match those calculated on the calibration sheet. Recalibrate the gauge if the coefficients were entered correctly, as described in Section 3.1.9.4 on Page 19, Calibration.

3.1.9.4 Calibration

(From NOAA/ATDD & NCDC Climate Reference Network Documentation Manual)

Equipment

- 11 Troemer-certified machined brass 1000g calibration weights with an aluminum base/centering weight
- Computer with MS Excel and NERON GEONOR Calibration Sheet file

Test Method

The GEONOR Rain Gauge has a fill capacity of 12 liters. At 4°C, one liter of water weighs 1000g. The machined weights weigh 1000.0g ±0.1g and represent one liter of water. The known weights are added to the gauge and the output is recorded. From these values, calibration curves are developed using Excel's linear regression feature.

Test Procedure

1. Record all precipitation gauge serial numbers on the GEONOR precipitation gauge calibration sheet.
2. After the rain gauge has been properly installed and leveled at the test site, record the initial output. Carefully add the aluminum base/centering weight to the bucket, wait two minutes, and record the frequencies of the individual sensors. Carefully add the first brass weight, wait two minutes and record the frequency. Repeat ten more times to reach the maximum gauge capacity.

   Note: The weights should be added slowly and carefully to avoid breaking any of the vibrating wires.
3. Enter the values into the GEONOR calibration sheet Excel file, shown in Figure 7, to perform a second-order linear regression analysis to determine the equation to relate frequency to rainfall depth (Depth (mm) vs. F-Fo).
4. Enter the coefficients into the data logger's static parameters.

Form Date: 20060210

NERON GEONOR CALIBRATION SHEET

STATION ID	DATE	TECHNICIAN NAME(S)		TECHNICIAN AFFILIATION
NONO2	2006-02-16	H WESTBROOK, B FLEIG		QSS
VIB WIRE POSITION		VIBRATING WIRE SN	PRECIP SN	BUCKET SN
VWPCP2 (NW)		62004	50517002	50517002

F_0	A	B
1037.7	1.7100E-02	9.3510E-06

WEIGHT (g)	DEPTH (cm)	FREQ. (F) (Hz)		F - Fo (Hz)
0	0	1037.7	(= Fo)	0.0
1000	5	1293.0		255.3
2000	10	1503.4		465.7
3000	15	1685.9		648.2
4000	20	1848.4		810.7
5000	25	1997.1		959.4
6000	30	2134.8		1097.1
7000	35	2263.2		1225.5
8000	40	2384.3		1346.6
9000	45	2498.7		1461
10000	50	2610.9		1573.2
11000	55	2715.3		1677.6
12000	60	2816.4		1778.7

EQUATION : DEPTH = A(F - F0) + B(F - F0)^2
A = x coef., B = x^2 coef. and (F - F0) = x

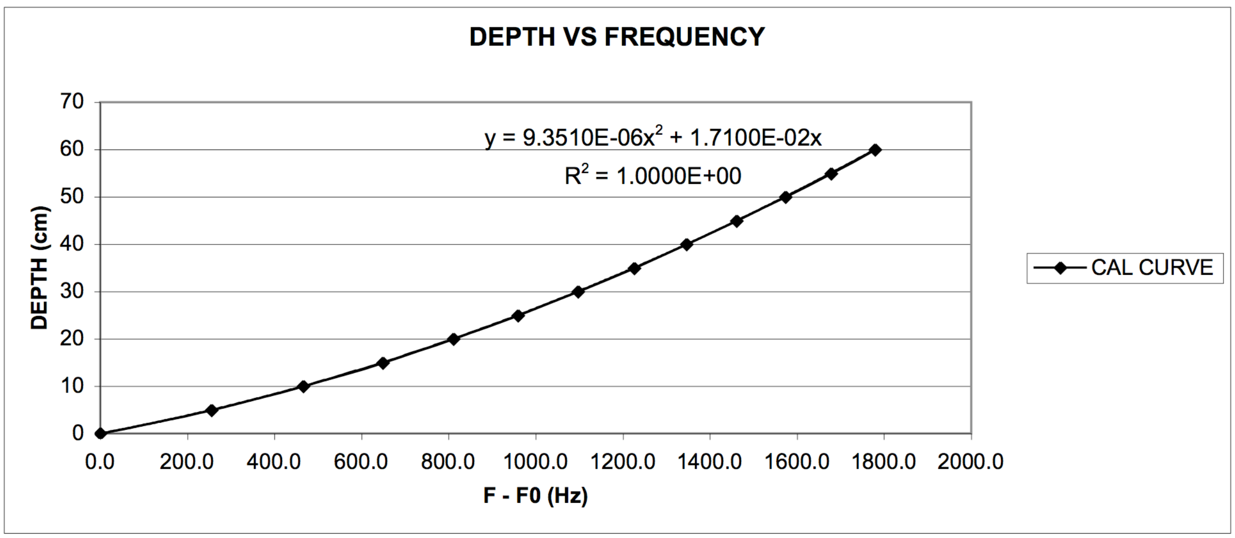

Figure 7. Sample input to and resulting calibration curve from the GEONOR calibration sheet Excel file.

3.1.10 Field Intercomparison of Sensors

(TO BE INSERTED)

3.1.11 Sensor Rotation Intervals

Replace sensors and return the removed sensors for recalibration, following the schedule in Table 1 below for specific sensor brands and models. These intervals reflect times after which sensor calibration drift can become excessive, based on practical experience.

Table 1. Rotation intervals for specific sensor brands and models.

Sensor	Rotation Interval (months)
Thermometrics PRT air temperature sensor	—
RM Young Wind Monitor direction indicator	48
RM Young Wind Monitor nose cone	36
RM Young Wind Sentry	18–24

Note: A range of rotation intervals means that rotation should occur at the smaller interval, if possible, but can wait until the longer interval has passed if inventory is not available.

3.1.12 Communication System Maintenance

Use an RF power meter placed between the transmitter and the antenna cable at sites with GOES or LETS radios. Verify that the meter is rated or set for the frequency range and power output of the transmitter. Measure and record the forward and reflected power in the “Arrival” row of the RF power table on the maintenance or site visit form. If any changes are made to the communication system during the visit, then perform and record the results of the final RF power test in the “Departure” row.

Table 2 below lists forward power (P_f) values and the corresponding reflected power (P_r) values for standing wave ratios (SWR) of 1.5:1, 2:1, and 3:1. For optimum communication quality, the SWR should be less than 1.5:1, though a value less than 2:1 is acceptable. If the SWR is 2:1 or greater but less than 3:1, then there is a problem that should be fixed soon, though the radio can continue to operate normally. If the SWR is 3:1 or greater, then the radio can be damaged and should be turned off immediately until the problem is fixed.

Table 2. Forward power (P_f) and corresponding reflected power (P_r) values for standing wave ratios of 1.5:1, 2:1, and 3:1 for radio-antenna systems.

P_f (W)	P_r 1.5:1 SWR (W)	P_r 2:1 SWR (W)	P_r 3:1 SWR (W)
10.0	0.40	1.11	2.50
9.0	0.36	1.00	2.25
8.0	0.32	0.89	2.00
7.0	0.28	0.78	1.75
6.0	0.24	0.67	1.50
5.0	0.20	0.56	1.25
4.0	0.16	0.44	1.00
3.0	0.12	0.33	0.75
2.0	0.08	0.22	0.50
1.5	0.06	0.17	0.38
1.0	0.04	0.11	0.25
0.8	0.03	0.09	0.20
0.6	0.02	0.07	0.15
0.4	0.02	0.04	0.10
0.2	0.01	0.02	0.05

Check all of the coaxial cable connectors for security, damage, corrosion, or bent center pins; check the antenna for damage; and check the entire length of coaxial cable for wear, damage, or cuts. Any of these conditions could attenuate RF signal power at the antenna and/or reflect power toward the transmitter, increasing the standing wave ratio and reducing transmission power further. Replace or repair damaged components and replace or clean corroded parts. In addition, if the SWR is too high, check that there are no nearby metal objects above, below, or to either side of the antenna.

3.1.13 Final Tasks

Before leaving a site for any kind of visit, complete the following:

1. Check all datalogger input locations for normal readings to ensure that all sensors are wired properly and are operating.
2. Verify that the station is communicating with the data monitoring and collection facility. If a GOES site, the next transmission window is more than a few minutes in the future, and changes have been made to the communication system since its last transmission, try at least to stay near enough to the station to come back if there is a problem with the next transmission.
3. Verify that all openings in the logger enclosure, if it is not outfitted with cable glands, are sealed with duct seal. In addition, verify that all conduit openings are sealed with duct seal to keep moisture out as much as possible.
4. Keep the logger enclosure door open until just before leaving the site. Upon leaving, record the departure time on the maintenance form and/or trouble ticket form(s), as indicated by the logger’s clock. This will allow QA personnel to confirm that the station sensor data has been flagged appropriately during the maintenance visit time.
5. Finally, lock the logger enclosure and all battery enclosures before departing.

3.2 Maintenance Performed by Site Hosts, Observers, or WFOs

Site hosts, observers, and WFO personnel are encouraged, but not required, to assist the maintenance contractors by performing preventive maintenance at sites.

3.2.1 Visit Schedule

Visits are suggested at the following times, driven by vegetation and precipitation gauge maintenance requirements. Note, however, that these visits must be coordinated with the maintenance contractor, so that the contractor can better schedule visits by its technicians.

- Whenever the vegetation on the site plot reaches a height of 12 inches or higher, to cut the vegetation
- Whenever the weighing bucket precipitation gauge's bucket is 75% full or more, to empty the bucket (WFO personnel only)

3.2.2 Documentation

All maintenance visits should be documented by completing and submitting the original NERON Site Maintenance Form for Hosts, Observers, and NWS WFOs, found in the forms section of this document to the NERON QA staff, preferably within 5 business days of performing the maintenance. The originals, not copies, should be submitted, so that they can be scanned and added to the electronic COOP metadata database. The following paragraphs explain how the maintenance form should be completed, item by item.

"Station ID" is the 3- or 5-character station identifier. Note the date and time of arrival and departure, in local STANDARD time (add one hour to local time during daylight saving time). Enter the name of the person performing the maintenance and circle the type of maintainer in the indicated boxes. Place "X's" in the check boxes next to each task completed.

1. Visual Inspection. The results of the visual inspection should be indicated with a "Y" for "yes" and an "O" for "no" in each box in the visual inspection section. All abnormalities and obstructions removed should be explained in the notes section at the bottom of the form.
2. Vegetation Maintenance. Mark the check box to indicate that the vegetation has been cut as specified in the vegetation maintenance section below.
3. General Maintenance. Mark check box next to each item that needed to be cleaned.
4. Precipitation Gauge Maintenance. Mark all of the applicable check boxes to indicate that all maintenance appropriate to the season has been completed. If adding antifreeze to the bucket, indicate the amount in liters.
5. Mark each check box to indicate that each final step was completed.

Finally, the person performing the maintenance should sign the form and enter the date of submission.

3.2.3 Visual Inspection

Inspect the equipment listed below for any abnormalities, or obstructions, noting any findings or actions taken to fix any problems on the site maintenance form:

- Mast or tower
- Logger and battery enclosures
- Sensor radiation shields
- All sensors, including sub-surface sensor plots
- Precipitation gauge
- All sensor and electrical cables
- Terrain in and surrounding the site plot
- Vegetation in and surrounding the site plot

3.2.4 Vegetation Maintenance

Cut vegetation to a height between 1 and 3 inches over the entire plot to provide a firebreak around the station equipment and to prevent the vegetation from growing high enough to impede wind flow to the above-ground sensors. Use either a string trimmer or a hand-pushed lawn mower.

3.2.5 General Maintenance

General maintenance includes cleaning the sensor radiation shields, the solar panel, and the pyranometer. Inspect the solar panel, if not a tall tower site, and the radiation shields and clean them if their surfaces are dirty or covered with snow. A radiation shield qualifies as dirty if there are any substances on it that are darker than its white surface, which could absorb solar radiation and heat the shield more than if clean, or if there are any objects that could obscure air flow over the sensor. A solar panel qualifies as dirty if there are any substances or obstructions visible that could reduce the amount of solar radiation reaching the solar cells.

Check the pyranometer lens for dirt and clean it by spraying it with a small amount of water and wiping it clean with a soft paper towel. It qualifies as dirty if there are any foreign substances or objects visible on the lens.

3.2.6 Precipitation Gauge Maintenance

(Adapted from NOAA ATDD "Precipitation Gauge Maintenance Guide")

1. Refer to the maps in the Precipitation Gauge Antifreeze Guide in the Site Maintenance Plan Appendices to determine the station's climate division. Find the climate division's entry in the antifreeze table, which is also located in the precipitation gauge antifreeze guide in the appendix, and read straight across to determine the add mixture date and the amount to add. Remove the mixture at the remove mixture date. If the current date is later than the remove mixture date and earlier than the add mixture date (warm months), then skip to step 3.

   Note: The antifreeze to be used is propylene glycol.

2. Refer to the Material Safety Data Sheets for proper handling procedures. Pre-measure the required amount of anti-freeze mixture for the precipitation gauge, using a 2-liter measuring beaker. An additional bucket will be required if more than 2 liters of antifreeze must be added.

3. Pump the liquid from the gauge into a bucket that can hold at least 3.5 gallons, as shown, using the gauge siphon.

4. Dispose of the liquid. If the liquid is water only, then pour into a storm drain or spread on the ground. If the liquid contains anti-freeze, then pour it into a carboy for proper disposal.

5. Slowly pour the new anti-freeze mixture into the top of the gauge, if the current date is later than the add mixture date and earlier than the remove mixture date (cold months).

3.2.7 Reporting Problems

Site hosts and observers should report any problems noticed at a site that could affect any sensor readings or the operation of the station by phone or email to the Data Acquisition Program Manager (DAPM) at the local National Weather Service forecast office. The DAPM should then relay any reports to the NERON QA staff. In the event that the local DAPM is unavailable or unable to relay problem reports, site hosts and observers should contact the QA staff directly via the NERON Operations and Monitoring system at 405-325-4538.

Each report should include as much detail as possible about the problem, if known, including station ID, start date, end date, equipment and/or sensors affected, and a description of the problem.

4 Problem Fixes

4.1 Problem Reporting

Problem reporting between the NERON QA staff and the maintenance contractor is two-way. QA staff will report problems noticed by the data monitoring/QA facility and those reported by sites hosts, observers, and WFOs and their required fix dates to the maintenance contractor. The maintenance contractor will report any problems noticed that could affect any sensor readings or the operation of the station, even if already fixed, to the NERON QA staff. Each report should include as much detail as possible about the problem, if known, including station ID, start date, end date, equipment and/or sensors affected, and a description of the problem.

4.2 Documentation

Problem reports from the QA and NERON Operations and Monitoring System staff will be made using the NERON trouble ticket system, which is part of the NERON metadata database. When a trouble ticket is issued an email notification of the problem will be sent to all affected maintenance contractors. The contractors may then access the trouble ticket information using the database's web interface. Technicians report problems found in the field to NERON QA and Operations staff by completing an electronic version of the trouble ticket and submitting it to the ISOS/NERON FTP site.

Problem fixes are also reported to the NERON QA and Operations staff by completing an electronic version of the trouble ticket and submitting it to the FTP site. If a printed paper version of the form is used by the technician in the field, the information entered by the technician must be transcribed to the electronic version and uploaded to the FTP site. All forms and photos should be submitted to the FTP site, as described in Section 5, Submission of Documentation, on Page, 57 within 5 business days after completing the fix. The following paragraphs explain how the trouble ticket forms should be completed, item by item.

The NERON Trouble Ticket Form is used for reporting a single problem at a single site, reporting the fix of a single problem. If reporting multiple problems at a single site, fill out one trouble ticket form per problem.

The NERON Trouble Ticket Form for Mass Installs, Fixes, or Moves is used to save paper and time when installing, fixing, or removing multiple pieces of equipment at once at a single site. When moving a site to a new location, use this form to document the serial numbers of all equipment removed. Use a separate copy of this form to document all equipment installed at the new location. This form should not be used for reporting a problem, unless it is also fixed at the same time that it is reported.

<u>Trouble Ticket/Site Visit Form</u>

1. Check the "Site Visit Only" check box if the form applies only to maintenance at a time other than the scheduled spring and fall maintenance visits, and no problems were fixed. If used for a problem fix during a scheduled maintenance visit, report the maintenance tasks completed on the NERON Site Maintenance Form for Technicians, rather than on this form.
2. Enter the 3- or 5-character station ID and circle "REMO" if a remote (weather) station, "RPTR" if a radio repeater site only, and "BASE" if a radio base station (LETS network

access point). If the date on which the problem began is known, enter it in the "DATE TRACED TO" box. If reporting a problem that has not yet been reported, enter the name of the person reporting the problem and the name of the organization with which the reporter is affiliated, if applicable; otherwise, enter "N/A". Enter the date the problem was noticed in the "DATE PROB NOTICED" box.

3. Circle or select (if filling out electronically) the equipment or sensor affected by the problem being reported. If the problem could be located in more than one item, and the specific item needing to be fixed is unknown, circle or select each item where the problem could be located. See Table 3 on Page 31 for an explanation of all of the equipment and sensor IDs.
4. Describe the problem as specifically and concisely as possible in the problem description area.
5. The box just above the heavy dotted line is reserved for use by the NERON QA staff.
6. If fixing a problem, enter the arrival and departure dates and times in UTC, as indicated by the data logger, the name of the maintenance contractor, and the name(s) of the technician(s) performing the fix.
7. If more than one sensor or unit of equipment is circled or selected in the problem report area, place an X over the single sensor or unit fixed. If multiple sensors or units were fixed to address this problem, use the form for mass installs, fixes, or moves.
8. Circle the appropriate type of fix: on-site repair (OSR), replacement (RPL), initial install (INI), removal (RMV), or no action taken (NAT). NAT should be used in situations where either the problem seemed to be with the sensor or unit of equipment marked on the trouble ticket form, but was actually with another sensor or unit of equipment, the problem resolved itself by the time the technician arrived, or, for some other reason, no action was taken on that particular sensor/equipment.
9. Enter the old and new sensor/equipment serial numbers, as applicable; the old serial number must be entered for OSR, RPL, RMV, and NAT, and the new serial number must be entered for RPL and INI. Do not leave any serial number information blank when it is expected.

   If an already installed sensor or unit of equipment does not have a serial number attached, use the following convention established for applying one on the trouble ticket and sensor tag:

   Do not install a new sensor or unit of equipment that hasn't had a serial number assigned and marked.

   If an old sensor or unit of equipment, which should be installed, is missing (i.e., due to theft), then circle RPL and enter "NONE" for the old serial number.

   Enter all leading zeros in serial numbers (e.g., the database *does* distinguish between 7 and 0007).
10. Describe the fix and any findings about the cause(s) of the problem in the fix description area.
11. If replacing or installing a new pyranometer or soil moisture sensor, contact an operator at the data collection facility to have the new serial number and calibration coefficients entered to maintain accurate real-time data. Note the name of the operator and the time called.

12. The box just above the heavy dotted line is reserved for use by the NERON QA staff.
13. If this is not a scheduled spring or fall maintenance visit, then fill out the bottom site visit portion of the trouble ticket.
14. Circle the purpose of the visit.
15. Indicate the results of the visual inspection with a "Y" for "yes" and an "O" for "no" in each box in the visual inspection section. All abnormalities and obstructions removed should be explained in the notes section at the bottom of the form.
16. Indicate the completion of cleaning and leveling, using a "Y" for "yes" and an "O" for "no" in each box in the tables.
17. When fixing a radio, antenna cable, or antenna problem at a site without a cellular modem, measure the forward and reflected RF power while transmitting before fixing the problem, if possible, and indicate the values in watts in the "Arrival" row of the table. Perform another test after the fix and enter the values in the "Departure" row. Due to the infrequency of GOES transmissions, a second RF test may not be possible but should be performed if reasonably possible.
18. If cutting the vegetation or replacing the desiccant, mark the appropriate check boxes.
19. If emptying the precipitation gauge bucket, adding antifreeze, and/or adding oil, mark the applicable check boxes. If adding antifreeze to the bucket, indicate the amount in liters. If a precipitation gauge calibration is performed as part of a problem fix or diagnostic procedure, enter the results of the calibration and include the serial numbers of the precipitation gauge base and bucket.

Table 3. Equipment types and parameter IDs used in the instrument database and on trouble ticket and metadata forms.

Equipment Type	**Parameter ID**	**Explanation**
DATALOGGER	LOGG	Data logger
WIRE_PANEL	WIRPAN	Data logger wiring panel (Used only for Campbell CR10X)
KEYPAD	KEYPAD	Logger keypad interface
PORT_MODULE	PRTMOD	Module add-on to expand data logger ports
MEMORY_MODULE	MEMMOD	Add-on memory module for data logger
MULTIPLEXER	MUX	Multiplexer
RADIO	RADIO	Primary data communication radio (LETS, CELL, or GOES)
RF_MODEM	RFMODM	RF modem, if a separate unit from the radio
RS-232_INTFC	RS232IF	RS-232 interface (required to interface RS-232 devices with Campbell CS I/O port)
GPS_ANTENNA	GPSANT	GPS antenna
SERIAL_SERVER	SERSRV	Serial server (base station equipment)
ETHERNET_HUB	ETHHUB	Ethernet hub or switch (base station equipment)
ROUTER	ROUTER	Ethernet router (base station equipment)

Equipment Type	Parameter ID	Explanation
SERIAL_RADIO	SERADS	Wireless serial radio installed at the station for communication with the site host's PDA
SERIAL_RADIO	SERADH	Wireless serial radio installed at the location of the site host's PDA
PDA	PDA	PDA used by the site host to communicate with the station
SOLAR_PAN	SOLRP	Primary solar panel; connected to the battery(ies) that is(are) connected directly to the data logger and that are isolated from the precipitation gauge heater
SOLAR_PAN	SOLRPS	Secondary solar panel; connected to the battery(ies) that is(are) connected directly to the precipitation gauge heater and that are isolated from the data logger
AC_TRANSFORMER	ACTRAN	AC 120V to DC ~15V transformer installed at AC-powered sites
SURGE_SUPPR	SRGSUP	Surge suppressor installed on the AC line at AC-powered sites and at base stations
TELNET_PWR_SW	TPS	Telnet or internet power switch (base station equipment)
VOLT_REG	VREG	Primary voltage regulator; connected to the battery(ies) that are connected directly to the data logger and that are isolated from the precipitation gauge heater
VOLT_REG	VREGS	Secondary voltage regulator; connected to the battery(ies) that are connected directly to the precipitation gauge heater and that are isolated from the data logger
BATT_CHRGR_AC	BATCHG	AC-powered battery charger
BATTERY	BATV	Primary battery voltage; measured from primary battery(ies), which is connected directly to the data logger and isolated from the precipitation gauge heater
BATTERY	BATVS	Secondary battery voltage; measured from secondary battery(ies), which is connected directly to the precipitation gauge heater and isolated from the data logger
PRT	TAIR1	1.5 meter air temperature reported by sensor number 1. If only one air temp sensor installed at a site, it takes this parameter.
PRT	TAIR2	1.5 meter air temperature reported by sensor number 2
PRT	TAIR3	1.5 meter air temperature reported by sensor number 3
PRECIP_GAUGE	PRECIP	The equipment type refers specifically to the precipitation gauge base, which, in the case of a vibrating wire weighing gauge, holds the vibrating wire sensors and the bucket; does not include the gauge cover. PRECIP refers to the 5-minute precipitation derived from VWFRQ1 through VWFRQ3 or after applying calibration coefficients to PCPTIP, depending on the gauge type, after ingest (see Table 3).

Equipment Type	Parameter ID	Explanation
PRECIP_GAUGE	PCPTIP	The number of tips reported since midnight UTC by a tipping bucket precipitation gauge
BUCKET	BUCKET	The precipitation gauge bucket
VIBRATING_WIRE	VWPCP1	Precipitation level indicated by precipitation gauge vibrating wire 1, the sensor oriented to the south. Also used to refer to the sensor itself.
VIBRATING_WIRE	VWPCP2	Precipitation level indicated by precipitation gauge vibrating wire 2, the sensor oriented to the northwest. Also used to refer to the sensor itself.
VIBRATING_WIRE	VWPCP3	Precipitation level indicated by precipitation gauge vibrating wire 3, the sensor oriented to the northeast. Also used to refer to the sensor itself.
VIBRATING_WIRE	VWFRQ1	Raw frequency reported by precipitation gauge vibrating wire 1, the sensor oriented to the south
VIBRATING_WIRE	VWFRQ2	Raw frequency reported by precipitation gauge vibrating wire 2, the sensor oriented to the northwest
VIBRATING_WIRE	VWFRQ3	Raw frequency reported by precipitation gauge vibrating wire 3, the sensor oriented to the northeast
WETNESS	WET1	Value 1 reported by the wetness sensor. Used as input to precipitation algorithm to prevent false increases.
WETNESS	WET2	Value 2 reported by the wetness sensor. Used as input to precipitation algorithm to prevent false increases.
WINDSENTRY	WS2M	2 meter wind speed
WINDMON_N	WSPD	Operational wind speed
WINDMON_D	WDIR	Operational wind direction
BAROMETER	PRES	Barometric pressure
PYRANOMETER	SRAD	Solar radiation
TEMP_RH	RELH, TSLO	Relative humidity with optional secondary slow-response air temperature
DEWPOINT	DEWPNT	Dewpoint
WATER_VAPOR	WTRVAP	Water vapor
SOILMOIST	VW03, TS03	Volumetric water and soil temperature under sod at 3 cm depth
SOILMOIST	VW05, TS05	Volumetric water and soil temperature under sod at 5 cm depth
SOILMOIST	VW10, TS10	Volumetric water and soil temperature under sod at 10 cm depth
SOILMOIST	VW20, TS20	Volumetric water and soil temperature under sod at 20 cm depth
SOILMOIST	VW50, TS50	Volumetric water and soil temperature under sod at 50 cm depth
PDA	SD06H	Snow depth, 6-hour
PDA	SD24H	Snow depth, 24-hour

Equipment Type	Parameter ID	Explanation
PDA	SF06H	Snowfall, 6-hour
PDA	SF24H	Snowfall, 24-hour
PDA	RVRSTG	River stage
PDA	REMARK	Observer remarks
PRECIP_GAUGE	BUKLVL	Precipitation bucket level in percentage full
PRECIP_GAUGE	BUKRES	Current reserve capacity of the precipitation bucket in mm
PRECIP_TEMP	TPRECP	Precipitation gauge rim or catch funnel temperature
PRECIP_HEATER	FLPHTR	Precipitation gauge rim or catch funnel heater flag value (this is not equipment that is tracked in the metadata database by serial number)
DOOR_SWITCH	FLDOOR	Door flag value (door switches are not tracked in the metadata database by serial number)
ASPIRATOR_FAN	FANSP1	Speed of primary air temperature aspirator fan
ASPIRATOR_FAN	FANSP2	Speed of secondary air temperature aspirator fan

<u>Mass Install, Fix, or Move Form</u>

1. Enter the 3- or 5-character station ID and circle “REMO” if a remote (weather) station, “RPTR” if a radio repeater site only, and “BASE” if a radio base station (LETS network access point). Enter the arrival and departure dates and times, as indicated by the station logger, if a remote station.
2. Enter the name of the maintenance contractor and the name(s) of the technician(s) performing the fix. The “ENTERED BY” and “DATABASE ENTRY” boxes are reserved for NERON QA staff use.
3. Describe the problem as specifically and concisely as possible in the problem description area. If the problem was originally reported on a Trouble Ticket/Site Visit Form, transcribe the description exactly.
4. In every row corresponding to a sensor or equipment to which the problem or job applies, enter the old serial number, new serial number, a short description, with OSR, RPL, INI, RMV, or NAT, as appropriate, at the front, and the trouble ticket number, if one has been issued. The “DB Updated” column is reserved for NERON QA staff use.
5. The blank rows at the bottom of Page 2 of the form can be used to enter information about new equipment that has not yet been included in the previous rows.

<u>Sensor and Equipment Tags</u>

Each sensor and unit of equipment listed on the trouble ticket forms must be accompanied by a tracking card when not installed at a station. The card should specify the sensor or equipment type, have fields for the serial number of the new sensor/unit, the serial number of the old sensor/unit replaced by the new sensor/unit, calibration coefficients of the new sensor, if applicable, the date the new sensor/unit was installed, the reason for replacement, any other pertinent information, and an area for notes. Examples are shown in Figures 10 and 11. A single tag can be used for both the new and old sensor/unit. It is simply transferred to the old sensor at the station where the replacement is made. This will ensure that the status of each uninstalled sensor/unit will be easily determined by anyone who handles it, and that calibration or repair facility people know how the sensor/unit should be processed, and will help them enter accurate information in the equipment tracking database.

FASTTHERM Calibration and Tracking Card
(*NOTE*- Resistor Pair # Matches Sensor #)

Serial Number_______________________________

Final Cal Date_______________________________

T-RMS___________________________________

Date to Cabinet_____________________________

****

Site Installed_____________________@Height________m

Date/Time Installed__________________________________

Tech(s) Installing____________________________________

FSTHRM Replaced (S/N)____________________________

Reason for Removal: TT Rotation Other(Please Explain)

TT Number (if applicable)____________________________

Number of Months in Field___________________________

Please use below and back for comments, notes, etc.

PYRA Calibration and Tracking Card

Serial Number_______________________________

Cal @ NRAD____/____/____to____/____/____.

Single Coeff__________________________

Poly Coeff C2__________________________

Poly Coeff C1__________________________

Poly Coeff C0__________________________

Resistor Value__________________________**Ω**

Date to Cabinet_____________________________

****

Site Installed_______________________________________

Date/Time Installed__________________________________

Tech(s) Installing____________________________________

PYRA Removed (S/N)________________________________

Reason for Removal: TT Rotation Other(Please Explain)

TT Number (if applicable)____________________________

Number of Months in Field___________________________

Please use below and back for comments, notes, etc.

Figure 8. Sample instrument tracking cards.

CR10X -2M Calibration and Tracking Car d

Serial Number____

NEW GOOD R E P A IRED

Repaired by: Mesonet CSI Other

Date Repaired________________________________

Date to Cabinet_______________________________

****

Site Installed____

Wire Panel Installed with (S/N)_________________________

Date/Time Installed___________________________________

Tech(s) Installing_____________________________________

LOGGER Removed (S/N)______________________________

Wire Panel (S/N)* if Removed__________________________

Reason for Removal: TT Rotation Other(Please Explain)

TT Number (if applicable)_____________________________

Number of Months in Field____________________________

(* If WP has no S/N, use logger S/N with 'WP' Prefix)
Please use below and back for comments, notes, etc.

P50 Radio Calibration and Tracking Card

Serial Number____

NEW GOOD REPAIRED

Repair/Calib by Mesonet Delmmar Other

Date Repaired______________ Tech___________________

2 CHANNEL RADIO

Channel #1 Frequency = 169.425

Channel #2 Frequency = 169.475

Date to Cabinet_______________________________________

****

Site Installed____

Date/Time Installed____________________________________

Tech(s) Installing_____________________________________

P50 Removed (S/N)_______________________________

Reason for Removal: TT Rotation Other(Please Explain)

TT Number (if applicable)_____________________________

Number of Months in Field____________________________

Please use below and back for comments, notes, etc.

Figure 9. Sample equipment tracking cards.

4.3 Serial Number Labeling of Sensors and Equipment

All sensors and all equipment listed on the NERON trouble ticket forms must have serial numbers assigned to them before they are installed so that they can be tracked accurately in the metadata database. However, if a sensor or unit of equipment is encountered in the field that does not have a serial number, the following convention should be used for assigning serial numbers to all equipment that do not have manufacturer-assigned serial numbers:

TTTYYMMDDSS###

where,

TTT = sub-type of equipment (see Table 4). Do not use unless Table 4 shows an entry for the equipment type. Use leading zeros if the sub-type is less than 3 digits.
YY = last two digits of year that the number was assigned
MM = month that the number was assigned
DD = day that the number was assigned
SS = two-letter abbreviation of the state in which serial number assigned
= number in the series of the specific kind of sensor or equipment. Use leading zeros if the number is less than 3 digits

The ### part allows the assignment of serial numbers to multiple units of the same equipment or sensor type at the same time. Simply use 001 for the first, 002 for the second, etc. One sensor type or equipment type can have the same serial number as a different type of sensor or equipment, since each unit of equipment is always referred to in the metadata database by both its equipment type and serial number. The only requirement is that sensors or equipment of the same type have unique numbers. Equipment with different sub-types are considered different types and can be assigned identical YYMMDDSS### portions of their serial numbers.

Table 4. Entries to use for the equipment sub-type portion when assigning a serial number to a sensor or unit of equipment.

Equipment Type	TTT
Solar Panel	Rating in watts
Battery	Amp-hour rating

Every sensor, except for barometers, should be labeled such that its serial number is printed on the cable end that is connected to the logger. The serial number should be printed on light-colored heat-shrink tubing, with an additional layer of clear heat-shrink tubing over the serial numbers to prevent them from being rubbed off or obscured. Sub-surface sensors that do not have their serial numbers stamped or etched on the sensor heads should have an additional label at the sensor end of the cable.

Every sensor or unit of equipment that is not installed inside an enclosure should have its serial number etched on its body, if possible. If the serial number is just printed on the body by the manufacturer or the manufacturer did not assign a serial number, then the installer should etch the serial number on an available non-sensitive surface. If etching is not possible, then the serial number should be printed on the cable, as described above. This will prevent problems with tracking sensors and equipment whose serial numbers have become unreadable due to weathering.

Examples:
The following examples indicate the proper assignment of serial numbers to equipment, when assigned in Tennessee on June 7, 2005:

First 84 amp-hour battery of the day to be numbered – 084050607TN001
First 26 amp-hour battery of the day to be numbered – 026050607TN001
First 50W solar panel of the day to be numbered – 050050607TN001
Second 50W solar panel of the day to be numbered – 050050607TN002
First air temperature sensor of the day to be numbered – 050607TN001
Second air temperature sensor of the day to be numbered – 050607TN002
First precipitation gauge base of the day to be numbered – 050607TN001

4.4 Fix Deadlines and Prioritization

Problem fixes must be accomplished by the fix due date determined by the NERON QA or Operations and Monitoring System for each problem and will depend on the date the problem was confirmed and the priority of the problem. The prioritization of problems and routine tasks is described in Table 5 below.

The NERON Operations and Monitoring System staff will report communication problems to the maintenance contractor by email – and phone for Category 1 Communication Problems – but the contractor is ultimately responsible for monitoring and following up on communication problems in their areas of responsibility using system reports and knowledge gathered while visiting stations in the field. The maintenance contractor should maintain a proactive role in the problem identification and resolution process, rather than waiting for specific reports from the Operations staff.

If multiple tasks of differing priorities come due at the same time and the maintenance contractor cannot complete them all by the due time, then the tasks should be completed in order of priority.

Table 5. Ranking of equipment problems and routine tasks by priority, with fix deadlines.

Priority	Problem/Task	Time to Fix (Business Days)
1	Severe communications or equipment problem. Any problem that could cause permanent loss of data or that completely prevents real-time data collection, which isn't resolved by remote equipment resets, if two-way communication is possible, cannot be attributed to atmospheric phenomena, and cannot be traced to hardware or software problems with the non-NWS components of the communication network or to the data monitoring and collection facility.	3
2	Empty a precipitation gauge bucket that is 75% or more full.	5
3	Significant problem impacting real-time data collection or charging failure of primary power system (VREG, BATV, ACTRAN, BATCHG). However, permanent data loss is unlikely.	5
4	Trouble ticket that affects TAIR1, TAIR2, TAIR3, both FANSP1 and FANSP2 at the same time, PRECIP, BUCKET, VWPCP1, VWPCP2, VWPCP3, WET1/2, LOGG, BATVS, RADIO, RFMODM, RS232IF, GPSANT, VREGS, SOLRP, SOLRPS, or FLDOOR.	10
5	Communication problem that prevents real-time data collection for a moderate percentage of the time.	10
6	Trouble ticket that affects WSPD, WDIR, WS2M, PRES, SRAD, RELH, DEWPNT, WTRVAP, TS05, TS10, TS20, TS35, TS50, VW05, VW10, VW20, VW35, VW50, FANSP1, or FANSP2.	20
7	Developing communication problem that has not yet significantly affected real-time data collection.	20
8	Scheduled maintenance – Spring maintenance is to be completed no later than two months following the "Remove Mixture Date" given in the precipitation gauge antifreeze guide in the appendix for each climate division. Fall maintenance is to be completed no later than the "Add Mixture Date" given in the antifreeze guide for each climate division. Scheduled maintenance at repeaters and bases must be completed once per year on a schedule at the discretion of the maintenance contractor.	See problem/ task description
9	Trouble ticket that affects **only** TSLO, WIRPAN, PRTMOD, MUX, SERSRV, ETHHUB, ROUTER, SERADS, SERADH, PDA, UPS, SRGSUP, TPS, TPRECP, or FLPHTR. If a problem with any of these were to adversely affect any higher-priority item, then the problem takes that higher priority.	30
10	Submit electronic documentation and photos following a maintenance visit or trouble ticket fix to the NERON QA staff	5
11	Low priority task specified at the discretion of the network manager, QA Manager, or Lead Operator (do not schedule a special visit)	Next site visit

4.5 Spare Inventory

To avoid unnecessary travel to fix unexpected problems encountered while away from home base, each technician should carry enough spare sensors and equipment to completely replace all of the sensors and electrical equipment at two remote stations, two repeaters, and two base stations. The repeater and base station requirement only applies to areas with LETS communication equipment. The spare inventory should cover every possible station configuration and should include at least one station's worth of each type of data logger, multiplexer, communication radio, antenna cable, antenna, battery, solar panel, voltage regulator, surge suppressor, and AC transformer.

In addition, each technician should carry at least one complete set of bolts, screws, nuts, and padlocks, if applicable, and a set of grounding hardware, including 4 AWG copper wire, lightning rod cable, and grounding clamps and acorns for each type and configuration of station.

4.6 Fix Procedures

4.6.1 Sensors

4.6.1.1 Air Temperature, Relative Humidity, and Dewpoint Sensors

1. Verify that the sensor wires and resistor leads are securely clamped by the wire terminals in the logger enclosure.
2. Verify that there are no obstructions to airflow through the radiation shield or over the sensor head. Document any significant findings photographically, as described in Section 3.1.3, Photographic Documentation, on Page 10, and remove any obstructions and clean any dirt found.
3. Check the sensor cable for wear, damage, or cuts, and replace the sensor if any are found.
4. If the problem cannot be repaired or the above checks do not uncover a problem, replace the sensor.

4.6.1.2 GEONOR Precipitation Gauge

1. Verify that the sensor wires are securely clamped by the wire terminals in the logger enclosure, at the terminal strip mounted to the rim of the gauge frame inside the gauge, and at each of the three green vibrating wire junction boxes inside the gauge.
2. Verify that the coefficients for each wire are entered correctly in the logger.
3. Verify that none of the wires inside the gauge are or could come into contact with the bucket, vibrating wire sensors, or the bucket support dish. Secure any loose wires to the gauge frame with cable ties or with electrical or other water-proof tape.
4. If the problem is an unexplained reduction in precipitation depth reported by the logger, verify that the bucket does not have a leak. Replace it and recalibrate the gauge, as described in Section 3.1.9.4, on Page 19, Calibration, if so.
5. When the logger excites the vibrating wire sensors, verify that each wire hums audibly. Measure the frequency at the transient arrestor Out +/Out - and VWG +/VWG – terminals, at the TH-501 A/B, and [V/B or E/F, whichever pair is connected to the logger] terminals.

   Measure the voltages across the Out + and Out - terminals, across the VWG + and VWG - terminals, and across the VWG + and Ground terminals at the transient arrestor box for each wire, and across the A and B terminals, across the D and E terminals, and across the C and E terminals at the TH-501 hybrid interface corresponding to each vibrating wire that does not hum when the vibrating wires should be excited.

   Measure the current draw of each sensor. When excited, the current draw of each wire should be between 1.5 and 1.8 mA.

   If current measurement is not possible or successful, measure the resistance through each sensor. With power disconnected from the vibrating wire circuit, the resistance across the leads connected to the TH-501 terminals A and B should be between 3.5 and 3.8 kΩ.

Test the diodes in the transient arrestor box, and in the TH-501 for each wire. Disconnect the transient arrestor box and TH-501 from the circuit. The passthrough voltage drop should be between 0.5 and 0.8 V. If the sensor output is intermittent or the sensor begins reporting frequency after cycling power to the sensor, there may be a faulty diode in the system.

Replace any wires, cables, transient arrestor boxes, or hybrid interfaces that are confirmed faulty as a result of these tests.

6. Replace any vibrating wire sensors that are still inoperative after replacing any faulty parts.
7. If any vibrating wire sensors were replaced, or the problem has not been diagnosed, calibrate the gauge, as described in Section 3.1.9.4, on Page 19, Calibration.

4.6.1.3 GEONOR Precipitation Gauge Rim Heater

(TO BE INSERTED)

4.6.1.4 2-Meter Wind Speed

1. Verify that the sensor wires are securely clamped by the wire terminals in the logger enclosure.
2. Verify that there are no obstructions, webs, or dirt affecting the cups. Document any significant findings photographically, as described in Section 3.1.3, Photographic Documentation, on Page 10, and remove any obstructions and clean any dirt found,.
3. Check for bearing noise that indicates the presence of dirt, which introduces excessive friction. Listen for a grinding or rattling sound. A clean hissing sound after a sensor has been deployed for a number of months is normal and does not qualify as "noisy."
4. Check the sensor cable for wear, damage, or cuts, and replace the sensor or repair the cable if any are found.
5. If the problem cannot be repaired or the above checks do not uncover a problem, replace the sensor.

4.6.1.5 Operational Wind Sensor Speed

10. Verify that the sensor wires are securely clamped by the wire terminals in the logger enclosure and at the junction box at the sensor end.
11. Verify that there are no obstructions, webs, or dirt affecting the propeller. Document any significant findings photographically, as described in Section 3.1.3, Photographic Documentation, on Page 10, and remove any obstructions and clean any dirt found.
12. Check for bearing noise in the propeller mechanism that indicates the presence of dirt, which introduces excessive friction. Listen for a grinding or rattling sound. A clean hissing sound after a sensor has been deployed for a number of months is normal and does not qualify as "noisy."
13. Check the sensor cable for wear, damage, or cuts, and replace the sensor or repair the cable if any are found.

14. If the problem cannot be repaired or the above checks do not uncover a problem, replace the propeller section of the sensor.
15. If replacing the propeller does not solve the problem, replace the entire prop-vane sensor.

4.6.1.6 Operational Wind Sensor Direction

1. Verify that the sensor wires are securely clamped by the wire terminals in the logger enclosure and at the junction box at the sensor end.
2. Verify that there are no obstructions or webs affecting the vane. Document any significant findings photographically, as described in Section 3.1.3, Photographic Documentation, on Page 10, and remove any obstructions found.
3. Check the sensor cable for wear, damage, or cuts, and replace the sensor or repair the cable if any are found.
4. Check the alignment of the vane. Use a bracket to immobilize the vane in a direction at least 10 degrees off of true north and use a compass accurate to one degree, taking magnetic variation into account, to check, and, if necessary, adjust the alignment.
5. If the problem cannot be repaired or the above checks do not uncover a problem, replace the direction potentiometer section of the sensor.

4.6.1.7 Barometer

1. Verify that the sensor wires are securely clamped by the wire terminals in the logger enclosure.
2. Verify that there are no obstructions blocking the sensor inlet tube. Document any significant findings photographically, as described in Section 3.1.3, Photographic Documentation, on Page 10, on Page 6, and remove any obstructions. Replace the inlet tube if the old one cannot be cleared completely or if it is worn or cracked.
3. Check the sensor cable for wear, damage, or cuts, and replace the sensor or repair the cable if any are found.
4. Run a field intercomparison with a reference barometer, if possible.
5. If tightening loose wire connections or clearing the inlet tube makes a noticeable difference in the BARO input location reading on the data logger, the intercomparison indicates a 5% or less error, and it isn't clear that the problem has been fixed, then call the QA Manager for guidance. Replacement may not be necessary.
6. If the problem cannot be repaired or the above checks do not uncover a problem, replace the sensor.

4.6.1.8 Pyranometer

1. Inspect the pyranometer level and check for bird droppings, debris, or dust and note anything out of the ordinary about the sensor, cable, or connections to the data logger on the site visitation report, pass form, or trouble ticket. Document any significant findings photographically, as described in Section 3.1.3, Photographic Documentation, on Page 10.

2. If the pyranometer (SRAD) input location reading on the data logger is negative, and a temperature and relative humidity (T&RH) sensor is installed, check the T&RH switch by disconnecting the T&RH's yellow wire from the data logger. If the RELH input location reading on the data logger is not 0.0000, then the T&RH switch is faulty and causing SRAD to indicate a negative number; replace the T&RH and recheck the SRAD reading.
3. Run a field intercomparison with a reference pyranometer, if possible.
4. If tightening loose wire connections, cleaning the pyranometer, or replacing the T&RH makes a noticeable difference in the SRAD input location reading on the data logger, the intercomparison indicates a 5% or less error, and it isn't clear that the problem has been fixed, then call the QA Manager for guidance. Replacement may not be necessary.
5. If replacing the pyranometer, put the protective cap from the new pyranometer on the old pyranometer, unwire it from the data logger, and remove it by loosening the allen set screw on the mounting plate.

   Note: It is important not to let anything except paper towels moistened with water touch the white translucent lens of the pyranometer because even small scratches can change the pyranometer's calibration.
6. Secure the new pyranometer to the mounting plate by tightening the set screw, coil up the excess cable, and wire it to the data logger.
7. Put a cap on the pyranometer that doesn't let any light through – wrapping black electrical tape around one of the red protective caps that comes with pyranometers works well – and check its input location on the data logger to verify that the reading is zero.
8. If the T&RH switch is good and the new pyranometer reading is slightly negative or positive – within 1.0 W/m^2 of 0 – then verify that the pyranometer's analog ground wire is connected to an analog ground port on the data logger near the analog port to which the analog data wire from the pyranometer is connected, and make a note of the reading on the trouble ticket.
9. Re-seal the data logger enclosure cable port with clay, if applicable.
10. Call the NWS data collection facility with the following information:
    1. Old pyranometer serial number
    2. New pyranometer serial number
    3. Site ID
    4. Time of fix as written on the trouble ticket
11. Note the name of the operator and the time of the call on the trouble ticket.

4.6.1.9 Soil Moisture/Temperature

Note: The soil moisture/temperature probe should be handled carefully to avoid bending the tines or nicking or scratching the sensor head from which the tines protrude. Bending the tines will cause erroneous readings, since they must be at a set distance from each other to obtain accurate soil capacitance and inductance readings. Deep nicks or scratches in the sensor head could expose the electronics to moisture, which would permanently damage the sensor.

1. Locate and mark the hole locations at the positions shown in Figures 3 and 5 and in Table 6 below.

Table 6. Soil moisture/temperature probe installation hole locations relative to the center of the tower.

Sensor Depth (cm)	Position E-W (ft)	Position N-S (ft)
5	5 W	13 S
10	3 W	13 S
20	1 W	13 S
35	1 E	13 S
50	3 E	13 S

2. Remove and set aside a 10-inch diameter sod plug for each hole, being careful to keep the sod as intact as possible to recover the hole when installation is complete.
3. Excavate the hole to a depth 10 inches greater than the sensor depth using a post hole digger or gas-powered auger. This will provide a collection area below the actual sensor for any water that seeps down the inner surface of the hole. Collect the excavated soil on a tarp, preserving the order of removal so that the soil stratification can be restored as much as possible when refilling the hole.
4. Take an approximately 4-cubic-inch soil sample at the sensor depth from the west, east, and/or north sides of the hole and place it in a plastic zipper-seal bag; label the station, depth, and date on the bag. Submit it to (TO BE INSERTED) for analysis.
5. Install conduit extending from the tower to just below sensor depth at the north side of the installation hole. Extend the conduit at least one foot above ground level at the tower end to prevent string trimmer or lawnmower damage to the cables. Cut and install a length of wire braid material to extend from the sensor to a few inches inside the end of the conduit to discourage burrowing animals from chewing through the cable. Feed the sensor cable through the conduit and push the metal braid a few inches into the conduit. Bury the conduit so that its top is at or below ground level, to allow a mower to pass over it.
6. Use a putty knife or paint scraper to smooth out the vertical surface on the south side of the hole at the sensor depth and to make it as vertical as possible.
7. Use a measuring stick and a straight edge placed horizontally at ground level at the top of the hole to determine the exact depth at which to install the sensor.
8. Insert the sensor horizontally into the soil, pointing south, at the proper depth. Do not move the sensor from side-to-side or wiggle it as it is inserted, as this could bend the tines and will form air pockets that will cause erroneous readings. In hard or rocky soils, use the Hydra Probe Jig to make pilot holes for the tines.
9. Route the sensor cable so that a drip loop is formed below the sensor.

Figure 10. Vertical cross-section showing hole dimensions and conduit, cable, and sensor placement. (TO BE INSERTED)

10. Wire the sensor to the data logger and perform a soil moisture cycle to check its operation. Initiate the cycle by entering (TO BE INSERTED) via the keypad. The cycle will occur during the next complete (TO BE INSERTED) second execution interval.
11. Backfill the installation hole with excavated soil in reverse of the order it was removed to preserve the soil stratification, making sure to tamp the soil well. Add water to help the soil settle.
12. Place a plot marker 12 inches due north of the hole center and mark the depth of the sensor on the top of the marker with a paint pen.
13. Replace the sod plug and repair the cut between the sod plug and the surrounding soil.

4.6.2 Electronic Equipment

4.6.2.1 Data Logger

(TO BE INSERTED)

4.6.2.2 Multiplexer

(TO BE INSERTED)

4.6.2.3 Raven CDMA Modem

1. Verify that both the logger and CDMA modem have power. The PWR LED on the modem should be lit.
2. Use a cable tester or continuity tester to test the cables connecting the logger and modem, modem and radio, or logger and radio, as applicable, if they might be causing the problem.
3. Troubleshoot the power system, as described in Section 4.6.3.1 on Page 56, if a solar system, and in Section 4.6.3.2 on Page 56, if an AC system.
4. Verify that the modem's Chan, Link, and Reg LEDs are lit and that the RSSI LED is blinking or lit. See Table 7 below for the meaning of each LED.

Table 7. Raven CDMA modem LED indications (from AirLink Communications Raven and PinPoint CDMA User Guide Version 1.12).

LED Label	Meaning
Chan	Flashing: searching for a channel On: found a channel
Link	On: 1x or CDMA service is available on this channel
Reg	On: PPP link is established on CDMA network and have an IP address
RSSI	Off: signal strength < -100 dBm Blinking every 1200 ms: signal strength -99 to -90 dBm Blinking every 600 ms: signal strength -89 to -80 dBm Blinking every 300 ms: signal strength -79 to -70 dBm On: signal strength ≥ -69 dBm
TxRx	On if transmitting or receiving
ERR	(not used)
PWR	On if power on

5. If the Chan and Link LEDs are lit but the Reg LED is not, verify that the modem is properly configured.
6. If the Chan LED is flashing, the Link LED is off, or the RSSI LED is off or blinking at only 1200 ms intervals, then check all of the coaxial cable connectors for security, damage, corrosion, or bent center pins; check the antenna for damage; and check the entire length of coaxial cable for wear, damage, or cuts. Replace or repair damaged components and replace

or clean corroded parts. In addition, check that there are no nearby metal objects above, below, or to either side of the antenna.

7. Verify that the antenna is pointing in the proper direction and is the proper type for the RF path.
8. If the problem still has not been corrected, then install and configure a known good modem. Replace the old modem if the problem persists.
9. Check to see if the CDMA network is experiencing an outage that could be causing the problem.

4.6.2.4 GOES Transmitter

Note: When troubleshooting, if a piece of equipment is replaced that doesn't fix the problem and isn't known to need repair, then return the original piece of equipment to the system to allow the problem to be localized and fixed without multiple return trips and to prevent returning working equipment for needless testing.

<u>Procedure</u>

1. Verify that all remote station equipment (logger and GOES transmitter) has power and is turned on and that the transmitter is properly connected to the logger.
2. Troubleshoot the power system, as described in Section 4.6.3.1 on Page 56, if a solar system, and in Section 4.6.3.2 on Page 56, if an AC system.
3. Data logger:
    a. Verify that the data logger has power.
    b. Connect to the logger with a laptop or keypad display and view current data to verify that it is operating properly.
4. Transmitter:
    a. Verify that the GPS antenna is connected. The transmitter will not transmit without a valid GPS fix.
    b. Verify that the transmitter has a GPS fix and hasn't logged any errors. Investigate all errors logged.
    c. Verify that the transmitter is configured to transmit in Pseudo Binary mode and that the correct NESDIS ID, window, interval, transmit time (offset), channel, and baud values are programmed.
    d. Use a cable tester or continuity tester to test the cable connecting the logger and the transmitter.
5. Antenna System:
    a. Perform an SWR test, as described in Section 4.6.2.7, on Page 54, Radio-Antenna System SWR Test.

4.6.2.5 Initial LETS Communication System Troubleshooting

The following are procedures that will be performed by data monitoring facility personnel. They are included in this document for the information of the maintenance technicians.

1. Verify that the correct RF ID's for the base station, repeater, and remote station are entered in the communication server.
2. Try to eliminate the possibility of a problem with the base station:
    a. Often, problems with base communications can be corrected by first downloading new configuration information, and then performing soft and hard resets, including cycling the power, as necessary.
    b. If the base station serves stations that don't have communication problems, then the base is probably operating properly.
    c. If the base station can send clock checks to other remote stations through a backup link, then the base is probably operating properly.
    d. If RF tests from the base and a working repeater or remote station or from another base to the suspect base indicate that both the base and the nearest station can receive from each other well, then the base is probably operating properly. However, poor RF test statistics for base reception or nearest station reception can indicate a possible problem with the base's radio, antenna coaxial cable, or antenna. Keep in mind, though, that poor RF test statistics may be caused by poor atmospheric conditions or an RF path over a backup link that is marginal due to distance or terrain.
    e. If clock checks can be sent to the base station, then everything except the connection between the radio and the RF modem, radio, antenna coaxial cable, and/or antenna is probably operating properly.
    f. If it is only possible to telnet to the serial server at the base station, then everything except the serial server RS-232 port, base RS-232 interface, RF modem, radio, antenna coaxial cable, antenna, and the cables connecting them, is probably operating properly.
    g. If it is possible to ping the serial server at the base station, then everything except the serial server, base RS-232 interface, RF modem, radio, coax, antenna, and the cables connecting them, is probably operating properly.
    h. If it is possible to ping the LETS PC at the base station location, then everything except the connection between the serial server and the ethernet hub, serial server, base RS-232 interface, RF modem, radio, coax, antenna, and the cables connecting them, is probably operating properly.
    i. If it is not possible to ping the LETS PC at the base station location or the serial server, and the LETS network is not down, then the ethernet hub or the connection between the hub and LETS may be faulty. It is also possible that there are problems with any or all of the other base station components.
3. Try to eliminate the possibility of a problem with any repeaters:
    a. If a repeater serves stations that don't have communication problems, then the repeater is probably operating properly.

b. If a repeater can send clock checks to other stations – through a backup link, if available and necessary – then the repeater is probably operating properly.

c. If RF tests through a repeater to other stations – through a backup link, if available and necessary – indicate that both the repeater and at least one of the stations it transmits to can receive well, then the repeater is probably operating properly. However, poor RF test statistics for repeater reception or nearest station reception can indicate a possible problem with the repeater's radio, coax, or antenna. Keep in mind, though, that poor RF test statistics may be caused by poor atmospheric conditions or a marginal RF path over a backup link due to distance or terrain.

d. If all of the stations served by a repeater are experiencing a communication outage, and if RF tests to the repeater from its base or another base through a backup link always fail, then it is possible that there are problems with any or all of the repeater components.

4. Try to eliminate the possibility of a problem with the remote station(s):

   a. If a different base is able to set the clock at a remote station through a backup link, then the remote station is probably operating properly.

   b. If the primary base is able to send a good RF test to the remote station or if a backup base with a possibly marginal link is able to send any kind of RF test to the remote station, then every communication component except the data logger, the cable between the logger and the RF modem, and the logger communication port on the RF modem is probably operating properly.

5. If the problem cannot be resolved remotely by calling LETS personnel, then visit the station(s) most likely to be causing the problem. (Refer to the appropriate procedure: base station, repeater, or remote station troubleshooting)

4.6.2.6 LETS Remote Station Communication Equipment

Use the Initial LETS Communication System Troubleshooting procedure in Section 4.6.2.5 on Page 50 as a guide to determine which remote station component is most likely to be causing the problem and troubleshoot that component before moving on to other components.

Note: When troubleshooting, if a piece of equipment is replaced that doesn't fix the problem and isn't known to need repair, then return the original piece of equipment to the system to allow the problem to be localized and fixed without multiple return trips and to prevent returning working equipment for needless testing.

Procedure

1. Verify that all remote station equipment (logger, RF modem, radio) has power and is turned on.
2. Use a cable tester or continuity tester to test the cables connecting the logger and modem, modem and radio, or logger and radio, as applicable, if they might be causing the problem.
3. Troubleshoot the power system, as described in Section 4.6.3.1 on Page 56, if a solar system, and in Section 4.6.3.2 on Page 56, if an AC system.
4. Data logger:
   a. Verify that the data logger has power.
   b. Connect to the logger with a laptop or keypad display and view current data to verify that it is operating properly.
5. Radio:
   a. Verify that the rainbow cable securely connects the RF modem and the radio. The rainbow cable connector should be turned clockwise as far as it will go at the radio end, and there should be a cable tie around the rainbow cable connector and the antenna connector to ensure a positive connection.
   b. Verify that the Carrier Detect LED on the RF modem flashes on for one second, off for one second, and on for one second when the RF modem's blue cable is initially plugged in to the data logger. Other flashing patterns indicate problems with the PROM or the modem. If replacing the PROM with the proper version (see **c.**) doesn't fix the problem, then replace the RF modem.
   c. Verify that the RF modem has a version 4 PROM (the label on the chip will have two numbers printed on it: 6873 and 04 – a version 8 PROM must be used if the station's RF ID is greater than 128) and that the PROM and memory chips are pushed in securely (the memory chip is located next to the PROM and is the same size).
   d. Verify that the dip switches on the RF modem are set correctly to correspond to the base station's RF ID. (See Setting RF95T RF ID Reference.)
   e. Verify that the radio is set to the proper frequency.
6. Antenna System:
   b. Verify that the radio is turned on and that the squelch is set properly, if applicable.

c. Verify that the Carrier Detect LED on the RF modem lights when the radio's squelch is broken by turning the squelch knob counter-clockwise or when the radio receives a signal. If the LED does not light, there could be a problem with the RF modem, the cable connecting it to the radio, or the cable ports on either the RF modem or the radio.

d. Perform an SWR test, as described in Section 4.6.2.7, on Page 54, Radio-Antenna System SWR Test.

e. If a solar-powered site, and the station has periodic outages during the mid-day hours but troubleshooting hasn't found any problems, then high voltage may be reducing the radio's receiver sensitivity when the solar panel is producing peak power. To solve the problem, install a voltage regulator between the radio and the power supply.

4.6.2.7 Radio-Antenna System SWR Test

1. Use an RF power meter placed between the transmitter and the antenna cable at sites with GOES or LETS radios. Verify that the meter is rated or set for the frequency range of the transmitter. Measure and record the forward and reflected power in the "Arrival" row of the RF power table on the maintenance or site visit form. If any changes are made to the communication system during the visit, then perform and record the results of the final RF power test in the "Departure" row.

   Table 8 below lists forward power (P_f) values and the corresponding reflected power (P_r) values for standing wave ratios (SWR) of 1.5:1, 2:1, and 3:1. For optimum communication quality, the SWR should be less than 1.5:1, though a value less than 2:1 is acceptable. If the SWR is 2:1 or greater but less than 3:1, then there is a problem that should be fixed soon, though the radio can continue to operate normally. If the SWR is 3:1 or greater, then the radio can be damaged and should be turned off immediately until the problem is fixed.

   Table 8. Forward power (P_f) and corresponding reflected power (P_r) values for standing wave ratios of 1.5:1, 2:1, and 3:1 for radio-antenna systems.

P_f (W)	P_r 1.5:1 SWR (W)	P_r 2:1 SWR (W)	P_r 3:1 SWR (W)
10.0	0.40	1.11	2.50
9.0	0.36	1.00	2.25
8.0	0.32	0.89	2.00
7.0	0.28	0.78	1.75
6.0	0.24	0.67	1.50
5.0	0.20	0.56	1.25
4.0	0.16	0.44	1.00
3.0	0.12	0.33	0.75
2.0	0.08	0.22	0.50
1.5	0.06	0.17	0.38
1.0	0.04	0.11	0.25
0.8	0.03	0.09	0.20
0.6	0.02	0.07	0.15
0.4	0.02	0.04	0.10
0.2	0.01	0.02	0.05

2. If the SWR is too high, check all of the coaxial cable connectors for security, damage, corrosion, or bent center pins; check the antenna for damage; and check the entire length of coaxial cable for wear, damage, or cuts. Any of these conditions could attenuate RF signal power at the antenna and/or reflect power toward the transmitter, increasing the standing wave ratio and reducing transmission power further. Replace or repair damaged components and replace or clean corroded parts. In addition, check that there are no nearby metal objects above, below, or to either side of the antenna.
3. Once SWR has been minimized and is in the acceptable range, if the forward power is much lower than the radio's rated transmit power, then the radio should be replaced.

4. Verify that the antenna is pointing in the proper direction and is the proper type for the RF path.

4.6.2.8 PDA/Wireless RS-232

(TO BE INSERTED)

4.6.3 Power System

4.6.3.1 Solar

1. Verify that all cables connecting the charging source, regulator (if applicable), battery, data logger, modem, radio, and antenna are undamaged and plugged in to their proper connectors securely.
2. If the fuse between the battery and the logger enclosure is blown, locate and fix the cause, if any can be found, before replacing the fuse.
3. Verify that all power connections are free of corrosion and tight, and verify that all power wires are sound by checking for voltage drops across them with power applied or by checking resistance across them when disconnected. Replace or repair all wires that have high resistances, high voltage drops, or that cause voltage to fluctuate intermittently.
4. Verify that the voltage across the wires from the solar panel(s) when disconnected from the regulator is about 20 V in bright sunlight – the voltage will be lower or zero when the sun is low, below the horizon, or obscured by thick clouds, though it should be greater than 13 V in cloudy conditions. If a solar panel's voltage output is too low, verify that it is clean and undamaged and check its cable for damage.
5. Verify that the battery(ies) is(are) good. Remove the fuse between the regulator and the battery. Perform a load test on each battery with a 12-volt battery load tester that can be set at a range of amp ratings. The batteries must be fully charged to test them, so if there was little direct sunshine on the previous day and little during the current day, then the batteries cannot be tested. Choose the amp setting appropriate for the battery to be tested, which is determined by the current capacity of the battery. If the battery has a cold cranking amp rating, set the tester for half of that value. Load the battery for the time period specified in the tester instructions and read the voltage. Replace any batteries that fail the test.

   Replace the batteries that do not pass this test or if they have any cracks, leaks, or bulging or concave sides. If a battery is not old and passes the visual inspection, but has a low voltage output and hasn't had an unusually large current drain for an extended period of time recently, then the regulator should be replaced, too.
6. If the voltage across the wires from the solar panel is at least 18 V when disconnected from the regulator, then reconnect the solar panel to the regulator and remove the fuse between the regulator and the battery. If the output voltage from the regulator at the "BATT" terminals is 5 V or less, then replace the regulator – this test cannot be performed if the solar panel voltage is much less than 18 V when disconnected from the regulator. Replace the regulator if its temperature sensor or sensor cable is damaged.

4.6.3.2 AC

(TO BE INSERTED)

5 Submission of Documentation and Collected Data

All forms and photos documenting maintenance and problem fix visits should be submitted to the NERON QA staff within 5 business days after completing the maintenance or fix. Electronic versions of all required forms, which include provision for entering all required information electronically, will be supplied to the maintenance contractors. When scanning a form for submission because it is not possible to submit an electronic copy (e.g., the metadata form obstruction drawing), it should be scanned at 300 dpi in grayscale mode and submitted in JPEG format. All documentation should be submitted to the NERON QA staff in electronic form by FTP to the following address, using the username and password supplied by NERON (anonymous login will not allow access to the correct directories):

URL: ftp://isos.noaa.gov

Forms should be uploaded to the directory corresponding to the state in which the station is located within the "submitted_forms" directory. Photos should be uploaded to the directory corresponding to the state in which the station is located within the "submitted_photos" directory. Any data collected from a station's data logger should be uploaded to the "submitted_data" directory.

Whenever documentation is submitted to the FTP site, send an email notification to the QA staff for your area so that the metadata database can be updated as soon as possible.

Use the following naming convention for all forms submitted to the FTP site, except for precipitation gauge calibration forms, whose convention will be explained below:

STIDYYYYMMDDFT.xxx

where

STID = the 3- or 5-character station ID
YYYY = year maintenance or fix completed
MM = month maintenance or fix completed
DD = day of the month maintenance or fix completed
FT = form type (see Table 9 below)
xxx = document extension (e.g., doc, pdf, jpg)

Table 9. Entries to use for the form type portion of an electronic form name.

Form	FT
Remote Station Maintenance Pass Form for Technicians ("Maintenance Pass")	MP
Repeater and Base Station Maintenance Form for Technicians ("Repeater/Base Maintenance Pass")	RBMP
Remote Weather Station Maintenance Form for Site Hosts and Observers ("Host Maintenance")	HM
Metadata Form	MD

Use the following naming convention for precipitation gauge calibration forms:

EQTYPE_SN_YYYYMMDD.xxx

where,

> EQTYPE = the equipment type of the unit being calibrated (VIBRATING_WIRE for a GEONOR gauge; PRECIP_GAUGE for a weighing bucket gauge where the weighing mechanism is an integral part of the gauge)
> SN = the sensor serial number
> YYYY = year of calibration
> MM = month of calibration
> DD = day of calibration
> xxx = document extension (which should be "xls" in most cases)

<u>Example:</u>
The following example indicates the proper naming of documentation for a fictional visit to North Foster, RI (FTFR1) on June 6, 2005:

FTFR120050606MP.doc – remote station maintenance pass form completed by a technician
FTFR120050606HM.doc – remote station maintenance form completed by a site host, observer, or WFO
FTFR120050606MD.doc – metadata form
VIBRATING_WIRE_69304_20050606.xls – GEONOR calibration sheet for wire 1
VIBRATING_WIRE_71004_20050606.xls – GEONOR calibration sheet for wire 2
VIBRATING_WIRE_71104_20050606.xls – GEONOR calibration sheet for wire 3